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ABSTRACT

A Study was conducted to determine the effects of saliency, concept rule, and stimulus variety upon number of trials to solution and focusing strategy. A prediction of special interest was that there would be a concept rule x saliency interaction. A 2 x 2 x 3 design combined concept rule (conjunctive, inclusive disjunctive), saliency ("high" and "low" determined by mean performance of "SS" in preliminary research), and stimulus variety (intradimensional shift, interdimensional shift, and no shift). Sixty college students completed a warm-up problem, a training problem, a shift problem (or no shift in the case of controls), and a transfer-to-new-stimuli problem. Dependent measures were analyzed. Focusing measures represented a technique for separating aptitude and attentional factors in concept learning. Results suggest that (1) traditional expectations of the conjunctive rule, which indicate that the most direct test yields the greatest information, do not apply to 2-dimension concept attainment tasks; and (2) greatest focusing on a transfer task can be achieved with small shift paradigms (change in solution only). Methodological implications include application of regression analyses to focus strategy research. (Author/TA)

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LEARNING AND TRANSFER IN CONCEPT IDENTIFICATION AS A FUNCTION OF CONCEPT RULE, SALIENCY, AND STIMULUS VARIETY

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Institute for Child Study
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Bloomington, Indiana

September, 1971

U.S. DEPARTMENT OF
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*Now at the Research and Development Center, University of Texas.

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Chapter 1

Theoretical Rationale

Experiments in concept identification by Conant and Trabasso (1964), and Haygood and Bourne (1965) have expanded the initial work of Bruner, Goodnow, and Austin (1956) by introducing concept rule as a variable. These experiments, as well as investigations by Hunt, Marin and Stone (1966), have established an order of difficulty for the conjunctive rule, inclusive disjunctive rule, exclusive disjunctive rule, and biconditional rule.[1] Hunt et al. (1966) have logically depicted the relative difficulty of these concepts with "decision trees." These trees register the number of interior nodes (decisions); the number, in turn, is taken as an index of difficulty. The index shows that the conjunctive and inclusive disjunctive rules are of equal difficulty, and that the exclusive disjunctive and biconditional rules, although more difficult than the former pair, are, in themselves, of equal difficulty.[2] Empirical investigations have tested the validity of this logical index of difficulty by measuring the number of trials to concept identification. Investigations by Conant and Trabasso (1964), Haygood and Bourne (1965), Neisser and Weene (1962), and empirical work by Hunt with artificial intelligence and human subjects (1966) refute the theoretical order of difficulty stated by Hunt (1962) and Quine (1958). The empirical results of these investigations have shown that the number of trials to solution increases across the conjunctive, inclusive disjunctive, exclusive disjunctive and biconditional rules, respectively. The results are contrary to the logical explications of concept rule stated by Hunt and Quine, explications which lead one to believe that the conjunctive and inclusive disjunctive pair are equal in difficulty and that the exclusive disjunctive and biconditional pair are also equal in difficulty.

Selection strategies. Related investigations have centered upon the psychological variables which might account for the discrepancy between the logical and psychological in-

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[1]For the conjunctive rule, when A and B are values of given dimensions, A plus B is correct; for the inclusive disjunctive rule, A or B or both is correct; for the exclusive disjunctive rule, A or B, not both, is correct; and for the biconditional rule, A plus B or neither A nor B is correct.

[2]See Appendix A for decision trees representing the conjunctive, inclusive disjunctive, exclusive disjunctive, and biconditional rules.

dicators of concept rule difficulty. Laughlin and Jordan (1967) report a significant interaction between the number of relevant dimensions (two or four) and concept rule (conjunctive, inclusive disjunctive, and biconditional) as well as a significant difference for selection strategies (focusing vs. scanning) across concept rules.

Advantages of using selection strategies have been described by Bruner et al. (1956). Laughlin and Jordan (1967), and Laughlin et al. (1968) quantified focusing and scanning and defined the process of focusing as the case in which the learner finds a positive instance to use as a focus, and then makes a sequence of choices, each of which alters a single value of a single dimension. In a further study Laughlin and Jordan (1967) found strength of focusing to vary inversely with the number of trials to solution. The stronger the subject focused on specific values and tested these, the lower his number of trials to solution.

Attentional and associational subprocesses. Additional research by Zeaman and House (1963), has centered upon the ability of some children to disregard irrelevant stimuli. Zeaman and House, working with a group of retarded children, segregated them in terms of the day in which the children reached a learning goal. This procedure, in effect, divided the children into slow, average, and fast concept solvers. Learning curves were then constructed for each of these groups. All the curves showed two distinct portions: the initial phase, which was flat and where performance was near the chance level, and a second phase, which showed a sharp rise to criterion. Zeaman and House identified these two portions of the curve as two subprocesses. The first they saw as an attentional phase, where the problem solver failed to attend to the relevant attributes, and the second, as an associational phase, in which the problem solver found the relevant attributes and quickly sorted through the possible values to find the criterial ones. Zeaman and House indicate that the flat attentional phase results from the child's failure to focus on the relevant cues, while the rapidly rising part of the curve reflects the associational phase; a phase wherein the child grasps the relevant dimensions and systematically sorts through the alternative solutions.

Zeaman and House constructed backward learning curves by setting the groups at criterion and counting the number of trials each group performed before reaching criterion. The slopes of the curves were steep rising and virtually identical for all groups. The initial phases, however, were considerably different; fast learners had short initial phases, and slow learners had long initial phases.

The results suggest that children's learning deficits may not be caused by their inability to form associations or to solve problems, so much as by their inability to attend to the critical features of a task. Thus, one might hypothesize that students who learn a biconditional concept fail to attend to the relevant dimensions as quickly as do students learning an exclusive disjunctive concept. Both groups, however, may have identical second phases or steep rising slopes. Similar attentional behavior may explain why the conjunctive and inclusive disjunctive rules have been found unequal in difficulty, despite decision tree analyses by Hunt (1962) and Quine (1958) which lead one to believe these rules can be equated. An interaction of attentional factors with concept rules may be a source of the discrepancies in concept difficulty noted by Conant and Trabasso (1964), Haygood and Bourne (1965), and Neisser and Weene (1962).

Transfer in concept identification. Transfer is important to all learning and particularly to concept identification. Contrary to Piaget's conceptions, Gelman (1967) has indicated that children can solve conservation problems more easily when they have been trained to attend to one dimension rather than another. In this research, practice sessions which cued the subjects to the relevant dimension significantly improved their problem solving performance. The results suggest Gelman was able to train children to attend to particular dimensions and that this training could be transferred to a new instance of the same concept in which the irrelevant, but not the relevant dimensions, changed.[3] Similarly, investigations by Trabasso and Bower (1968), and Zeaman and House (1963) have indicated that focus cuing can shorten the subprocess of learning to attend to the relevant stimuli.

Implications for learning concepts. Current concept identification studies have at least two implications for school-related learning. First, if learners are to respond to similar stimuli in generalized ways, stimulus displays must provide optimal transfer. Stimuli must reflect a minimum increase in the attentional phase of concept attainment (Trabasso and Bower, 1968; Zeaman and House, 1963) and a maximum strength of focusing (Laughlin, 1966; Laughlin and Jordan, 1967; Laughlin *et al*., 1968). Second, strength of focusing, found to be significant in

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[3]Piagetian concepts would suggest that long term learning in Gelman's study must be the product of the interaction of training paradigms and the maturational factors of cognitive growth. Critical experiments for these hypotheses have yet to come forth.

Laughlin's work, may be dependent upon attentional factors which interact with concept rule. The different attentional behavior of learners may reflect the different number of trials to solution across concept rules. One strategy for identifying procedures which best manipulate attentional behavior is to determine appropriate ways to vary the stimulus dimensions within any given concept rule. This implication predicts an interrelationship between concept rule, saliency, and stimulus variety.

Major Variables

Concept rule. Four concept rules have been studied repeatedly in a large number of concept identification experiments. These concept rules are unique in that (a) the corpus of concept research has included these rules, thereby providing reliable data as to their characteristics with learners, and (b) the concept rules consist of two pairs which can be logically but not psychologically equated (Conant and Trabasso, 1964; Haygood and Bourne, 1965; and Neisser and Weene, 1962). These pairs consist of the conjunctive and inclusive disjunctive rules, inclusive disjunctive being the more difficult, and exclusive disjunctive and biconditional rules, biconditional being the more difficult. The conjunctive rule requires the union of two relevant values for its solution (A plus B), while the inclusive disjunctive rule requires one value or the other value or both values for its solution (A or B or both). The exclusive disjunctive rule requires one value or the other value but not both values for its solution (A or B, not both), and the biconditional rule requires both values or neither value for its solution (A plus B, or neither A nor B).

A characteristic of the inclusive disjunctive rule, but not the conjunctive, is that one must lean heavily upon information derivable only from negative instances. In order to know what the class is like, one must begin by learning what the class is not like. Therefore, the number of negative instances sampled in presolution trials may directly effect the learner's rate of attaining the inclusive disjunctive concept. Conant and Trabasso (1964) examined conjunctive and disjunctive concept attainment under equal-information conditions, where the minimum number of choices necessary for solution was equated between concept rules. Their results indicated that the disjunctive concept was more difficult to learn than was the conjunctive concept. However, the reason for this difference in difficulty is not known.

The importance of negative instances, where the learner attends to irrelevant dimensions, is not as clear for the biconditional concept rule as it is for the inclusive disjunctive rule. However, in the biconditional rule a correct instance may contain neither A nor B. Therefore the irrelevant dimensions may allow the learner to see dimensions other than A and B long enough for him to discover an equally effective solution with instances containing neither A nor B. The speed with which the learner discovers that either A and B or neither A nor B can solve the task determines the relative ease or difficulty of solving the concept rule. The reliance upon negative instances for solution of the inclusive disjunctive rule and the possible advantage of sampling dimensions outside the hypothesized relevant dimensions for the biconditional rule, suggest a link between the discrepancy in difficulty between the conjunctive and inclusive disjunctive rules, and the exclusive disjunctive and biconditional rules.

Saliency. While attending behavior has been ably studied in the psychological literature, its meaning has varied from one era to another. In its earliest conception it was given a high status by William James (1890) when he wrote a descriptive account of the operation of attention in his Principles of Psychology. For James the interaction of interest and experience brought forth predictable attending behavior. More recently, Woodworth and Schlosberg (1954) have reviewed a wide range of investigations in attention. Their report is somewhat pessimistic, and from it we learn that both the Gestalt and behavioristic movements have failed to deal extensively with attentional behavior, the former because any attentional force is extraneous to the "field forces," and the latter because of its traditional mentalistic definitions.

Although stimulus saliency, as a variable useful in predicting attending behavior, has not generally been studied with concept identification tasks, Bruner et al. (1956) have attached some relevance to this variable, and have studied it in the context of concept learning. These researchers used schematized pictures of children and adults, seemingly interacting in various ways, to convey themes or stories. The familiar bases of grouping material provided in the thematic instances led certain dimensions to have nonrational criteriality. That is, the subjects attended to these dimensions and formulated hypotheses around them, whether or not they tended to be the criterial dimensions needed to solve the concept task. More recently, researchers in the area of attention in learning have selected saliency as a primary research variable. Trabasso and Bower (1968) have reported a series of experiments in which both transfer effects and learning were significantly influenced by the saliency of dimensions. In one study the amount of transfer was found to be directly related to the saliency of the transferred cue and inversely related to the saliency of the irrelevant cue. Other studies by Trabasso and Bower (1968) have emphasized the effects of saliency on the learner's ability to discriminate between relevant and irrelevant cues. Saliency for these studies was a function of the number of irrelevant dimensions. By adding or removing irrelevant dimensions, the researchers either retarded or enhanced learning. It is important to note that the authors of this research dealt with relevant redundant cue tasks in which two cues were always relevant, and that the subjects discriminated between these relevant cues and the irrelevant ones. These studies did not call for the combination of dimensions required by the conjunctive, inclusive disjunctive, exclusive disjunctive, and biconditional concepts. Moreover, saliency was a function of the number of irrelevant dimensions. This method could not be used to manipulate saliency within the higher order concept rules without confounding results. The procedure, in effect, requires that the number of dimensions within a concept be varied, thus creating several levels of difficulty for the same concept. Kepros and Bourne (1963) have already found a strong and direct relationship between number of irrelevant dimensions and concept difficulty with a higher order rule.

With increasing evidence that attentional factors must be considered in concept identification research, reliable indices are needed to identify the saliency characteristics of different cues. Archer (1962), Shepp and Zeaman (1966), and Suchman and Trabasso (1966) have investigated various saliency hierarchies. Archer has reported on the effect of variation in size upon discrimination of the size cue, while Shepp and Zeaman have reported a brightness-size hierarchy for retardates. Suchman and Trabasso have reported hierarchy data for color, size, and form, as well as symmetry and asymmetry.

Future research dealing with higher order concept rules may need to construct a larger hierarchy of cues. Such a hierarchy would be one wherein all or most of the commonly employed dimensions used in concept learning studies would be described in terms of their relative saliency. Quantitative scaling methods would allow for the relatively finer and more precise manipulation of saliency than has typically been the case, where only "high" and "low" values have ordinarily been used. In addition the proposed research should be cast in a developmental framework in order to determine how saliency changes as a function of age, as has been suggested by Brian and Goodenough (1929) and, more recently, Suchman and Trabasso (1966).

Stimulus variety. Generally research studies using transfer of training paradigms have dealt with two classes of conditions in which transfer can occur. The first class, derived from "S-R" studies, is based upon the similarity of stimulus, response, and associational features of the original and transfer tasks. The second class deals with commonality of rule, and consists of a series of problems which are defined by a common underlying rule. Transfer, here, is dependent upon rule learning. While the first class can involve discrimination without generalization, the second class requires generalization (Bourne, 1966), for to learn a rule is to learn a generalization. When transfer takes place on the second level, it is because the learner has discerned a common rule (or rules) in several tasks.

There has been a basic controversy about the efficacy of single problem paradigms (same dimensions over trials) and multi-problem paradigms (varying dimensions over trials). Research by Adams (1954) has suggested that better transfer is attained with the single problem paradigm, while the research of Callantine and Warren (1955) has suggested the opposite. Morrisett and Hovland (1959) clarified the issue when they hypothesized that a training condition intermediate between the single and multi-problem procedures would do best of all. Morrisett and Hovland's hypothesis was that optimal transfer would occur when subjects were exposed to a variety of stimuli. The subjects (_S_s) were, however, given sufficient practice with each stimulus so that they might achieve a moderate to high degree of learning. As expected, _S_s whose training provided a high degree of learning within a single problem as well as a generalized experience with several problems, made fewest errors on the transfer task.

The research upon which these conclusions are based employed elementary concept tasks in which dimensions were sorted into "correct" and "incorrect" categories. Concept rules which employ combinations of dimensions would provide more complex learning tasks for testing Morrisett and Hovland's conclusion.

Dimensions in higher order concept identification tasks can be made to vary in several ways, each way introducing greater stimulus variety into the concept learning task. The most simple transfer task is one that changes an irrelevant dimension _intra_-dimensionally. If, for instance, color has been an irrelevant dimension with two values, red and green, then the transfer task would insert two new values of the same dimension in place of red and green. The change is wholly within the color dimension. A second transfer task may change an irrelevant dimension _inter_-dimensionally. If, for instance, color has been an irrelevant dimension with two values, red and green, then the transfer task would insert two new values from a previously neutral dimension in place of red and green (e.g., small and large). A third transfer task may change both the relevant and irrelevant dimensions. Here, the learner must apply the same concept rule in a totally new stimulus environment.

School activities involve concept learning tasks and the transfer of these concepts to new tasks and to new stimulus environments. Precisely what method may best achieve this transfer is unclear. Intra- and inter-dimensional shifts are important during the course of concept learning in that they can provide the learner with sufficient variety so that transfer may be attained with new stimuli.

Summary and implications for research. In teaching concepts it is important to identify the optimal context in which to present various concept identification tasks. To provide this optimal context, research must (a) determine the effect of saliency upon observed differences in various concept rules and (b) determine the training modes which foster the greatest amount of transfer to a new stimulus environment with the same concept rule. The studies undertaken and reported herein are an attempt to ascertain the interactions, and therefore interrelationships, between concept rule, saliency, and stimulus variety.

Two studies that examined these variables were conducted in a sequence which allowed the first study to determine the procedures employed in the second. The first study examined the saliency characteristics of an array of dimensions useful in the construction of concept learning tasks. The major outcome was a saliency hierarchy of selected dimensions. The second study used the hierarchy to manipulate saliency in the relevant and irrelevant positions of conceptual tasks which employed different concept rules and varied levels of stimulus variety. The following chapter reports the first of these studies.

Chapter 2

Functional Saliency of Selected Dimensions[4]

Studies examining the saliency of color, form, and size, have indicated the hierarchical arrangement of these dimensions. In an early study Brian and Goodenough (1929) manipulated two- and three-dimensional objects and found a color/form hierarchy for children. Using triad preference tests, the authors reported a preference for color between the ages of 3 and 6, and a preference for form in children over 6 yrs. of age. Recent studies by Corah (1964) and Suchman and Trabasso (1966) support the finding that preference for color changes to a preference for form at about age 6.

Problem

The present study expands the traditional color/form research to provide preference indices for color, form, borders, lines and dots. Research suggests that form is preferred to color for learners over 6, but few studies have measured preferences for other stimuli. The present study investigated five dimensions by submitting pairs of these to preference tests. Different values (subsets) of the form dimension were constructed to assess the preference for alternative modes of representing this dimension. The purpose of the study was (a) to determine if preferences for selected dimensions are constant for preschoolers and adults, (b) to examine color and form preferences in combination with other dimensions, and (c) to determine if preferences for dimensions in pairs can be generalized to more complex combinations of dimensions. Predictions were: (a) form would be dominant for adults and color dominant for preschool children, (b) other dimensions studied would be preferred differently by preschool and adult groups, and (c) preference for a dimension in a pair can predict preference for the dimension in the context of a larger number of dimensions.

Method

The experiment had a 2 x 7 factorial design, with Age (preschool and adult) and Problem Sets (triadic combinations) as the two factors.

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[4]The reader may also wish to see, Borich, Gary D., "Preferences for color, form, borders, lines and dots by preschool children and adults," Perceptual and Motor Skills, 1970, 31, 811-817.

Preference Test

Six sets of three figure patterns were constructed (after Bruner, Goodnow, and Austin, 1956; Trabasso and Bower, 1968), each arranged so that two pairs had different dimensions in common. A seventh set was arranged so that three dimensions were in common among pairs. The stimulus patterns differed in binary values of color (red and green), form (triangle and circle), borders (presence or absence), interior lines (presence or absence), and dots (presence or absence). Colors were selected for maximum contrast and represented primary colors with strong saturations. Colors were Red No. 130 and Green No. 63 in the color chart in the unabridged edition of Webster's New International Dictionary (Neilson, 1950). To eliminate confounding due to position effect, each of the seven patterns was drawn on six different cards; each card represented one of six possible positions for the three figures in the pattern. The seven stimulus patterns appear in Fig. 1.

Subjects

Ss were 25 preschool children attending a $2\frac{1}{2}$-hr. session as part of an elementary school program and 25 graduate students. The mean ages for the preschool and adult groups were 4 yr. and 9 mo. and 26 yr. and 3 mo., respectively.

Testing Procedure

Adult Ss were administered the seven sets of stimulus patterns in a classroom setting. The 42 stimulus patterns (seven patterns in six positions each) were photographed from 5- x 3-in. cards with white backgrounds from which color slides were constructed. Adult Ss saw the slides as a class and viewed one slide in each set before the sequence was repeated five more times. Adult Ss responded on a prepared response sheet which required Ss to connect with a line the two figures which seemed most similar. No verbal labels of the dimensions were required or encouraged. The positions of the figures on the screen were represented with the numbers 1 to 3 on the response sheet as they appeared on the screen. Each slide was projected for 5 sec., followed by a 5-sec. response time, both being automatically controlled. Ss were asked if the projection and response time were sufficient; no S thought that they were not. Preschool Ss were shown the same material but individually tested, using the 5- x 3-in. cards from which the slides were constructed. The sequence of administering the patterns was unchanged except for the instruction to Ss which was now orally presented by E.

Results

Analyses were based on summed choices for each dimension over Ss. Mean scores for the preschool and adult groups and problem sets appear in Table 2.1.

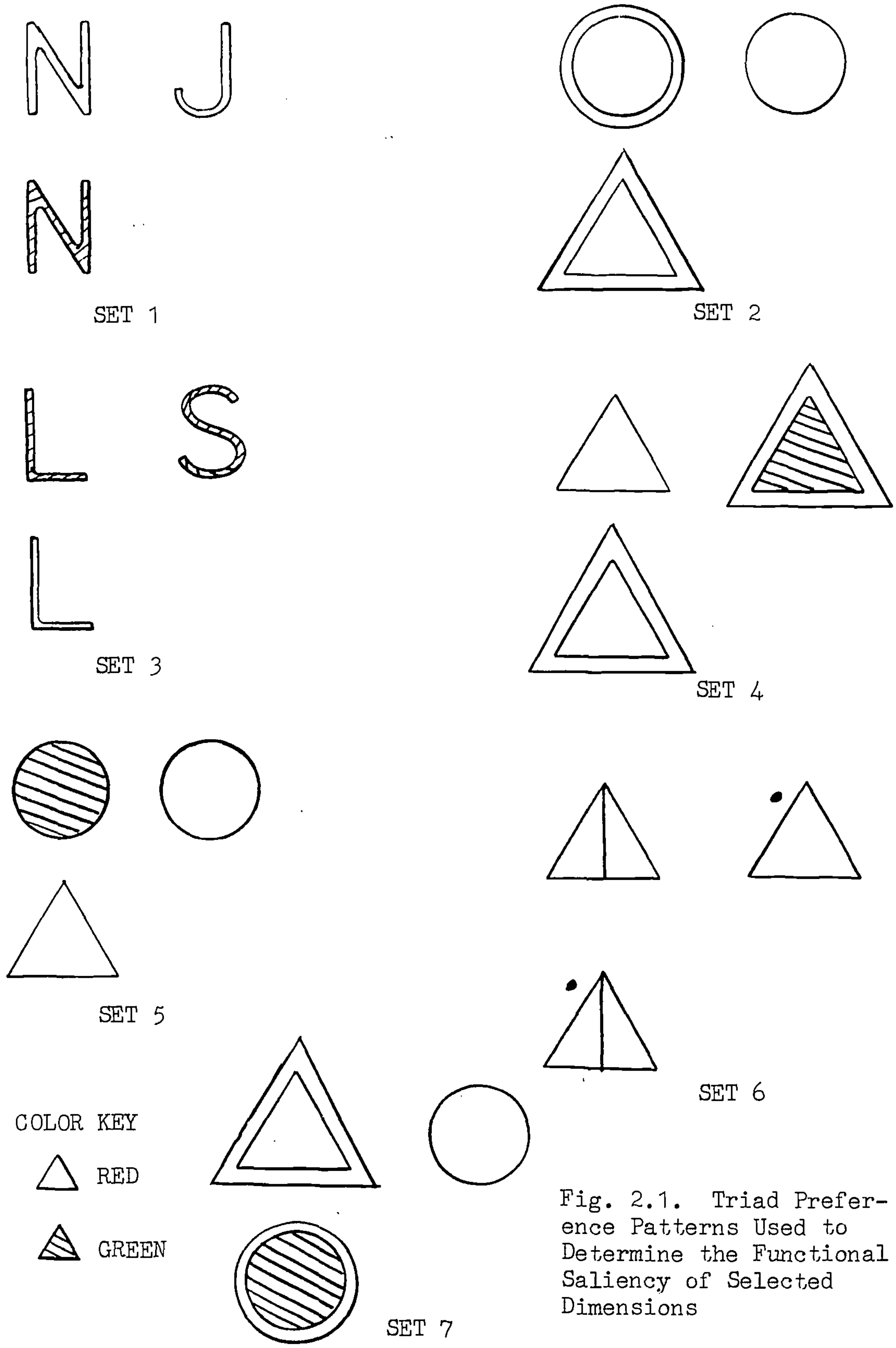

Fig. 2.1. Triad Preference Patterns Used to Determine the Functional Saliency of Selected Dimensions

TABLE 2.1

Mean Scores for Preschool and Adult Groups for Response Alternatives by Problem Sets (Maximum Cell Score = 6.00)

Set	Dimensions	Preschool	Adult
1	Color	0.80	1.40
	Form	5.16	4.52
	No preference	0.04	0.08
2	Form	5.44	2.80
	Borders	0.40	3.00
	No preference	0.16	0.20
3	Color	0.40	1.12
	Form	5.60	4.84
	No preference	0.00	0.04
4	Color	1.60	0.96
	Borders	4.28	5.04
	No preference	0.12	0.00
5	Color	0.68	1.32
	Form	5.24	4.64
	No preference	0.08	0.04
6	Lines	5.48	3.16
	Dots	0.36	2.68
	No preference	0.16	0.16
7	Color	0.84	0.76
	Form	4.96	2.00
	Borders	0.20	3.12
	No preference	0.00	0.12

c. Age X Problem analyses for Sets 1, 3, and 5 treated Problems as a within-groups factor and Age as a between-groups factor. For these sets, color and form were compared with three variations of form: Set 1, "N" and "J", Set 3, "L" and "S", and Set 5, circle and triangle. Results of the analysis of variance for form responses appear in Table 2.2. The main effect for Age across the three problem sets was not significant, although adults chose color more often than did the preschool children. Varying form, however, did significantly affect preference for form in Set 3: "L" and "S" in Set 3 was chosen significantly more often than "N" and "J" in Set 1 ($\underline{F} = 6.56$, $\underline{df} = 2/96$, $\underline{p} < .05$). Other comparisons and the interaction were not significant.

TABLE 2.2

Analysis of Variance for Problem Sets 1, 3, and 5 for Form Responses

Source	SS	df	MS	F	p
Between (Groups)	16.66	1	16.66	2.31	
Error (Between)	346.00	48	7.21		
Within (Sets)	3.88	2	1.94	3.53	$<.05$
Interaction					
Groups X Problems	0.17	2	0.09		
Error (Within)	53.28	96	0.55		

The analysis was repeated for color responses. Preschool children did not choose color significantly more often than adults ($F = 2.42$, $df = 2/96$), and the Problem X Age interaction was not significant ($F < 1.00$, $df = 2/96$).

Separate analyses were conducted for Sets 2, 4, 6, and 7 where response alternatives varied from form and borders (Set 2), color and borders (Set 4), lines and dots (Set 6), to color, form and borders (Set 7). The analyses of variance and response measures are summarized in Table 2.3

TABLE 2.3

Analysis of Variance Between Preschool and Adult Groups For Problem Sets 2, 4, 6, and 7

Problem Set	Source	SS	df	MS	F	p
2/Form	Between Groups	87.12	1	87.12	27.80	$<.01$
	Within Groups	150.24	48	3.13		
	Total	237.36	49			
4/Color	Between Groups	5.12	1	5.12	1.40	
	Within Groups	174.72	48	3.64		
	Total	179.84	49			
6/Lines	Between Groups	67.28	1	67.28	18.18	$<.01$
	Within Groups	177.60	48	3.70		
	Total	244.88	49			
7/Form	Between Groups	109.52	1	109.52	28.73	$<.01$
	Within Groups	182.88	48	3.81		
	Total	292.40	49			

Note.-For the alternative dimensions: Borders (Set 2), $\underline{F}$ = 28.50, $\underline{p} < .01$; Borders (Set 4), $\underline{F}$ = 1.92; Dots (Set 6), $\underline{F}$ = 20.80, $\underline{p} < .01$; Color (Set 7), $\underline{F}$ = 1.00; Borders (Set 7), $\underline{F}$ = 46.20, $\underline{p} < .01$.

For three of the four sets, there was a significant difference between preschool and adult responses. In Set 2 (form vs. borders), preschool children chose form significantly more often than adults; in Set 4 (color vs. borders), the $\underline{F}$ was not significant; in Set 6 (lines vs. dots), preschool children chose lines significantly more often than adults; and in Set 7 (color vs. form vs. borders), preschool children chose form significantly more often than adults. The analyses were repeated for the alternative response measures. The corresponding $\underline{F}$ ratios are presented as a note to Table 2.3.

TABLE 2.4

Proportions and Chi Squares for Response Comparisons

Set	Responses	Preschool		Adult		χ^2		
		N	P	N	P	Preschool	Adult	$\Sigma\chi^2$
1	Color	20	.13	35	.23			
	Form	129	.86	113	.76	79.74	41.11	120.85
2	Borders	10	.07	75	.50			
	Form	136	.90	70	.47	108.74	00.17	108.91
3	Color	10	.07	28	.19			
	Form	140	.93	121	.80	112.67	58.05	107.72
4	Borders	107	.71	126	.84			
	Color	40	.27	24	.16	30.54	69.36	99.90
5	Color	17	.11	33	.22			
	Form	131	.88	116	.77	87.81	46.23	134.04
6	Lines	137	.91	79	.53			
	Dots	9	.06	67	.44	112.22	00.99	113.21
7	Color	21	.14	19	.02			
	Form	124	.83	50	.33	73.16	12.16	85.32
	Color	21	.14	19	.02			
	Borders	5	.03	78	.52	9.85	35.89	45.74
	Borders	5	.03	78	.52			
	Form	124	.83	50	.33	113.50	6.12	119.62

Note.-$\chi^2_{.95}$ (1 $\underline{df}$) = 3.84.

Analyses to determine preference hierarchies for the seven sets of dimensions were computed with derivations of the chi-square procedure. Data were reduced to frequencies and a test for correlated proportions applied (Siegel, 1956). Proportions and chi squares for the response comparisons are presented in Table 2.4. Response alternatives for all seven sets were significant for the preschool Ss and for the sum of the chi squares. However, for the combined chi squares the preschool group contributed almost the entire sum for Sets 2 and 6. Disordinal and ordinal differences across preschool and adult Ss appeared for these sets respectively. The largest difference between response alternatives occurred for the form and color pairs represented in Sets 1 and 5.

Chi squares for the preschool, adult, and combined groups are arranged in hierarchies in Table 2.5. Pairs eligible to enter the hierarchy are those with dimensions which differed significantly. For the form/color comparisons, an "L"-"S", triangle-circle, and "N"-"J" order occurred. The form (L-S)/color comparison appears at the top of the hierarchy for the preschool and combined groups and second from the top for adults. An interesting result appears for the border/color comparison; for the preschool group, border/color is at the bottom of the hierarchy, while for adults it is at the top. For preschoolers most preferred is form when paired with color, while for adults most preferred are borders when paired with color.

TABLE 2.5

Hierarchy of Paired Comparisons for Preschool and Adult Ss And Their Sum

Rank	Set	Preschool	Set	Adult	Set	Sum
1	3	Form (L-S)/c	4	Borders/c	3	Form (L-S)/c
2	6	Lines/d	3	Form (L-S)/c	5	Form (Δ-O)/c
3	2	Form/b	5	Form (Δ-O)/c	1	Form (N-J)/c
4	5	Form (Δ-O)/c	1	Form (N-J)/c	6	Lines/d
5	1	Form (N-J)/c			2	Form/b
6	4	Borders/c			4	Borders/c

Note.-Most preferred response appears in full. For the alternative response c = color, d = dots, b = borders.

Set 7 constructed comparisons for color, form, and borders. Responses for these dimensions are indicated in Table 2,4, Set 7. For the preschool Ss, the order of the hierarchy is form, color and borders, while for adults it is borders, form and color. Differences in preschool and adult preferences for borders apparently have unequally altered the sampling probabilities of form and color for the two groups. The resultant sampling change places form at the top of the hierarchy for preschoolers, and borders at the top of the hierarchy for adults.

A mathematical model such as Luce's choice axiom (Luce, 1959) provides an equation which can test whether form and color responses in Set 7 can be predicted from form responses in Set 2 and from color responses in Set 4, where both dimensions are compared with borders.

The predicted values for form in the presence of color and borders, and for color in the presence of form and borders appear in parentheses in Table 2.6. While the predicted values are similar to the observed values, only for the form choice has the addition of borders altered the sampling probabilities as predicted by the Luce axiom. For form the obtained values were not significantly different from the predicted values. The data suggest that for form the sampling probabilities of complex combinations of stimuli may be predicted from the preference indices of paired comparisons.

TABLE 2.6

Predicting Form and Color Probabilities For Set 7 From Observed Values in Sets 2 and 4 With Luce's Choice Axiom

Set	Response Alternatives	Preschool	Adult
2 $p_{f,b}$	form/borders	.90	.47
4 $p_{c,b}$	color/borders	.27	.16
7 $p_{f,cb}$	color/form/borders	.83 (.87)	.33 (.43)
$p_{c,fb}$		.14 (.04)*	.02 (.09)*

Note.-Predicted values in parenthesis.
*$p < .05$ for obtained vs. predicted values.

Summary. The results have provided a rational basis for manipulating saliency in concept identification research when preference is taken as an index of saliency. Form can be considered a "high" salient dimension and color a "low" salient dimension when the two are paired. When the sum of preschool and adult performance was considered, form, represented by the letters "L" and "S", provided the greatest preference contrast. Therefore, saliency may be manipulated by assigning form to the relevant position and color to the irrelevant position in one treatment, and reversing these dimensions in a second treatment. The research described next will apply these results to a multivariate concept identification task in which color and form represent differing levels of saliency.

Chapter 3

Hypotheses and Method

The second study had two objectives: (a) to provide empirical data which would determine the importance of saliency in two logically equated concept rules, and (b) to determine training modes for these rules which would foster the greatest amount of transfer. The study investigated the main effects and interactions of three variables: concept rule, saliency, and stimulus variety. The major hypotheses were:

(a) Highly salient dimensions in the relevant position will result in fewer trials to solution for the conjunctive than for the inclusive disjunctive concept rule.
(b) Highly salient dimensions in the irrelevant position will result in fewer trials to solution for the inclusive disjunctive than for the conjunctive concept rule.
(c) The intradimensional shift condition will produce greater transfer of the concept rule than will either the no shift or the interdimensional shift condition.
(d) No shift in dimensions will produce greater transfer of the concept rule than will the interdimensional shift condition.

The study examined the interactive effects of concept rule, saliency, and stimulus variety. This was done in separate, first order analyses for the predictions in Table 3.1.

TABLE 3.1

Prediction of Main Effects and Interactions

Hypothesis	Main Effects and Interactions	Predicted Effect
1	Concept rule	Conjunctive easier than inclusive disjunctive easier than exclusive disjunctive easier than biconditional
2	Dimensional shifts (stimulus variety)	
	intradimensional shift	Improved transfer
	interdimensional shift	Retard transfer
3	Saliency	No main effect
4	Saliency x Concept rule	
	High salient relevant dimension	

	conjunctive rule	Improve learning
	inclusive disjunctive rule	Retard learning
	High salient irrelevant dimension	
	conjunctive rule	Retard learning
	inclusive disjunctive rule	Improve learning
5	Dimensional shifts x concept rule	No interaction
	Dimensional shifts x saliency	No prediction

<u>Statistical</u> <u>design</u>. The three variables of interest were manipulated in a 2 x 2 x 3 design with <u>S</u>s as the fourth factor. The three principal variables, concept rule, saliency, and stimulus variety, were fully crossed with <u>S</u>s nested within factors.

The two levels of concept rule were (a) conjunctive (A plus B is correct) and (b) inclusive disjunctive (A or B or both is correct).

The two levels of saliency were (a) "high" saliency and (b) "low" saliency. The saliency of the dimensions for this study was relative and was determined in a separate study reported as Chapter 2. As a result of this research, <u>E</u> chose a pair of dimensions for which preference was low for one dimension and high for the other. Pairs were manipulated so that a "high" salient and "low" salient dimension appeared respectively in the relevant and irrelevant positions of a two dimensional concept identification task.

The three levels of stimulus variety were (a) intradimensional shift, (b) interdimensional shift, and (c) no shift. A shift to new stimuli, in which both relevant and irrelevant dimensions changed, provided the transfer task for the stimulus variety conditions.

Six dependent measures determined the effects of the major variables. These measures were (a) number of negative instances to solution, (b) number of positive instances to solution, (c) total number of instances to solution, (d) time to solution in seconds, (e) strength of focusing on irrelevant dimensions, and (f) strength of focusing on relevant dimensions.

<u>A</u> <u>note</u> <u>on</u> <u>selection</u> <u>strategies</u> <u>and</u> <u>focus</u> <u>scoring</u>. By using a strategy efficiently, learners are able to increase the likelihood that instances chosen contain useful information, as well as assimilate and retain information with less strain.

Researchers in the field of concept identification commonly make reference to two different strategies: "scanning" and "focusing". The scanning strategy, in turn, includes two subtypes: "successive" and "simultaneous". When simultaneously scanning, S determines all possible hypotheses, using all combinations of dimensions and values in the stimulus display. Each positive instance that S chooses logically eliminates some percentage of the total possible number of hypotheses. S, then, recalculates the number of hypotheses that remain, and focuses his attention on these. The number of calculations that must be made to guarantee maximum information on the first choice increases for S as the task becomes more complex. For instance, in the conjunctive rule, if the task employs two didimensions with four values each, there are 16 possible hypotheses; and if the first card chosen is a positive instance, this logically eliminates 12 of these 16 hypotheses. S must, then, construct the four hypotheses that remain. If the task employs four dimensions with three values each, there are 255 possible hypotheses. In this case, the first positive card will eliminate 240 solutions. S must, then, construct the 15 hypotheses that remain. For complex problems, the manipulations and memory storage needed to construct the large numbers of possible hypotheses places simultaneous scanning beyond the abilities of most learners.

Successive scanning differs from simultaneous scanning in that only one hypothesis is tested at a time. The successive scanner limits his choices to those that provide a direct test of his hypothesis. He may choose an instance that was used at some previous time to test another hypothesis. Therefore, redundancy may be high, and the chance of S choosing instances which provide maximum information is uncertain. Just as there are two scanning strategies (the "successive" and "scanning" strategies just described), so, too, with focusing. The two focusing strategies are labelled "conservative" and "gambling". In conservative focusing, S makes a sequence of choices, each of which alters a single value of a single dimension (referred to hereafter as "dimension-value"); then he tests to see whether such a change yielded a positive or a negative instance. In focus gambling S changes two or more dimension-values, but the risk of not gaining information on the next instance is greater than it is for conservative focusing. When the number of dimensions and values is small, focusing offers the advantage that solution becomes virtually certain after a relatively small number of trials.

Laughlin and Jordan (1967) have quantified focusing according to two rules. The first rule requires that each card choice obtain information on one new value. For the conjunctive task, new information may be obtained in two ways: (a) if the card choice altered only one value (conservative focusing), or

(b) given the case that more than one value was altered (focus gambling), the instance was either positive, or the ambiguous information was correctly resolved on the next card by altering only one value. The second rule required that a hypothesis be tenable.[5] Similar procedures were applied to other concept rules. It is important to note that the authors scored focusing by three criteria: S had to (a) alter only one value (or more than one in the case of focus gambling), (b) alter a value that was not redundant and (c) state a tenable hypothesis. Therefore, if S were to state an untenable hypothesis, or alter a single value that was redundant, the trial could not be scored as a focus. Focusing consisted of S attending to a particular dimension as well as efficiently using the information gained earlier to choose a tenable hypothesis and/or nonredundant value.

An attentional and a cognitive factor are confounded in the Laughlin and Jordan scoring process. When variables are manipulated to ascertain their effect upon focusing, as the Zeaman and House (1963) research suggests, their effect must be free from uncontrolled differences in memory and information processing. In an attempt to determine the effect of saliency upon focusing, the Laughlin and Jordan scoring rules were revised so as to reduce the cognitive component in focusing. Focusing was scored solely according to the extent to which S altered one or more stimulus values of the same dimension in the conjunctive rule, or left one or more stimulus values of the same dimension unchanged in the disjunctive rule.

In considering either rule, it may be most efficient for S to focus upon or isolate values. In the disjunctive task, since only one correct value is necessary to make a positive instance in the two-dimension case, S gains most information by changing all but one value. Whether or not the next choice is a positive or negative instance is dependent upon this sole value. In the conjunctive task two given values are necessary for a positive instance. S cannot gain information by leaving only one value unchanged. The single value which the conjunctive S must focus upon, is, by necessity, that which he alters. For the present study, focusing consisted of altering values or leaving them unchanged, regardless of whether the values focused upon were redundant or the hypotheses stated tenable. Therefore, a trial was scored as a focus for the conjunctive rule when Ss,

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[5]A tenable hypothesis is one which has not been proved false by previous card choices.

1. changed any one value (conservative focusing), or
2. changed two values of the same dimension (focus gambling).

And, for the disjunctive rule when Ss,

1. left any one value unchanged (conservative focusing), or
2. left two values of the same dimension unchanged (focus gambling).

A S's final focusing score was the number of trials on which he obtained a focus divided by his total number trials for that problem. Focusing scores for the relevant and irrelevant dimensions were derived separately.

Subjects. Sixty students enrolled at Indiana University participated in the experiment. Ss who volunteered for the experiment were randomly assigned to the treatment groups. Before experimentation Ss were given a brief discrimination test with the identical hues and saturations used in the experiment. No Ss were rejected for color deficiencies. The Ss ranged in age from 19 to 57, with a mean of 25 years and 5 months and a median of 23 years and 10 months. Ss were compensated two dollars for participating in the experiment and were aware of their payment before volunteering.

Stimulus materials. Stimulus patterns used for the concept tasks were similar to those initiated by Bruner et al. (1956) and Trabasso and Bower (1968). These patterns consisted of form, color, borders, interior lines, and dots as the primary dimensions. Stimulus patterns were constructed with one relevant and one irrelevant dimension, each with two values. A third dimension remained neutral for control purposes. The third or quiet dimension provided a means by which Ss could identify the order of particular values in stating a final solution.

Five stimulus decks, each containing 16 stimulus patterns (cards), were used in the study. The first deck was a training deck used to acquaint Ss with the task and to provide a basis from which the first dimensional shift could be made. For this deck the form (L-S) and color (red and green) dimensions were manipulated in all possible combinations. Size remained neutral (quiet) for all decks. The dimensions were selected from Table 2.5 and represented two dimensions which differed significantly in saliency.

The second stimulus deck consisted of the same dimensions as the training deck, but triangles and circles replaced the letters "L" and "S" in order to provide the intradimensional shift for the stimulus variety variable. The "high" saliency characteristic of triangle and circle plus the "low" saliency characteristic of red and green are indicated in Table 2.5.

The third and fourth decks provided the interdimensional shift with (a) the shape and border dimensions and (b) the color and border dimensions. Shape and color were chosen as irrelevant dimensions for both saliency conditions in order to provide the same irrelevant dimensions as had previous decks. Although the border dimension was designated as relevant, its saliency characteristic changed across the border/shape, border/color combinations (see Table 2.5). When the border dimension was paired with color, S preference for borders was significantly greater than it was for color, but when the border dimension was paired with shape, S had no preference for one over the other. The results of this difference in saliency between pairs can be observed in the statistical analysis of decks three and four.

The fifth deck provided the transfer problem, with position of dots and interior lines as the criterial dimensions. Dots and lines represented an appropriate selection for the transfer problem, in that for adults their saliency characteristics did not significantly differ. Thus, they provided the opportunity to construct a transfer task unconfounded by saliency.

Five decks, containing 16 patterns each (all possible combinations), were constructed on 3 x 5 inch cards. The hues and saturations were identical to those used in assessing the saliency characteristics of the dimensions reported in Chapter 2. Patterns were constructed with templates on white backgrounds. The research design is summarized in Table 3.2.[6]

Procedure. Ss were tested individually with each of three stimulus decks. One group of 10 Ss received two training problems (T), followed by one problem with the intradimensional shift deck (D_1), which, in turn, was followed by the transfer-to-new-dimensions problem with the third deck (D_3). A second group of 10 Ss received two training problems (T), followed by one problem with the interdimensional-shift deck (D_2), which, in turn, was followed by the transfer-to-new-dimensions problem (D_3). A third group of 10 Ss received three training problems (T), followed by a transfer-to-new-dimensions problem with D_3. The procedure can be summarized in the following manner.

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[6]See Appendix B for the relevant values.

TABLE 3.2

The Three Principal Variables: Concept Rule, Saliency and Stimulus Variety

		Conjunctive				
Variety	Order[a]	Irrelevant Salient		Relevant Salient		Incl. Disj.
		Relevant	Irrelevant	Relevant	Irrelevant	
	T	Color	Shape	Shape	Color	
Intra-	T	Color	Shape	Shape	Color	
shift	D_1	Color	Shape	Shape	Color	
	D_3	Dot/Lines		Dot/Lines		
	T	Color	Shape	Shape	Color	
Inter-	T	Color	Shape	Shape	Color	
shift	D_2	Borders	Shape	Borders	Color	
	D_3	Dots/Lines		Dot/Lines		
	T	Color	Shape	Shape	Color	
	T	Color	Shape	Shape	Color	
Control	T	Color	Shape	Shape	Color	
	D_3	Dot/Lines		Dot/Lines		

[a]T = training, D_1 = intradimensional shift, D_2 = interdimensional shift, D_3 = transfer to new dimensions.

Intra-shift Group (Decks T,1,3)	Inter-shift Group (Decks T,2,3)	Control Group (Decks T,T,3)
Problem	Problem	Problem
1 training	1 training	1 training
2 training	2 training	2 training
3 D_1 (intra-shift)	3 D_2 (inter-shift)	3 training
4 D_3 (transfer)	4 D_3 (transfer)	4 D_3 (transfer)

The intra-shift, inter-shift, and control groups were further divided into two saliency levels in which (a) the relevant dimension was "high" salient and (b) the irrelevant dimension was also "high" salient. The procedure can be summarized in the following manner.

High Salient Irrelevant Dimension (shape)

Deck	Relevant	Quiet	Irrelevant	Shift
Training	Color	Size	Shape	
D_1	Color	Size	Shape	Intra-dimensional
D_2	Color	Size	Borders	Inter-dimensional
D_3	Dot/line	Size	Dot/line	

High Salient Relevant Dimension (shape)

Deck	Relevant	Quiet	Irrelevant	Shift
Training	Shape	Size	Color	
D_1	Shape	Size	Color	Intra-dimensional
D_2	Shape	Size	Borders	Inter-dimensional
D_3	Dot/line	Size	Dot/line	

The inter-dimensional-shift group received a T,T,D_2,D_3 order, the intra-dimensional-shift group received a T,T,D_1, D_3 order, and the control group received a T,T,T,D_3 order. For D_3, one value from the dot dimension and one value from the line dimension were relevant.

Ss were asked to report to an experimentation room on the University campus. Instructions similar to those reported by Conant and Trabasso (1964) and Laughlin and Jordan (1967) were read to Ss, but they were clarified and revised at some points.[7] After S acknowledged that he understood the instruc-

[7]See Appendix C for the conjunctive and inclusive disjunctive instructions.

tions, he was presented with the training deck for two problems. The second training problem differed from the first in that new correct values for the relevant dimension were chosen. The third problem introduced either the intra-dimensional-shift deck, or the inter-dimensional shift deck. The fourth or transfer-to-new-dimensions problem, was a control problem and, therefore, the same for all Ss.

S chose from among the 16 possible stimulus patterns; after which, E indicated whether the instance was correct or incorrect and left it in view of S. S continued at his own pace until the correct solution was verbalized. E recorded total time to solution, number of total trials to solution, and a pre-assigned number on the back of each card. Four binary digits were used to indicate the four dimension-values possessed by any given card, and when arranged in sequence, provided the format from which focus scores were derived.[8]

[8]For example 1100 = left figure red (1), triangle (1); right figure green (0), circle (0). While, 1100 in base ten = 03, the number recorded and then converted to its binary equivalent.

Chapter 4

Results

An analysis of variance for a two factor experiment was applied to problem 2; a three factor analysis was applied to problems 3 and 4.[9] Results of the analyses and mean scores for the six dependent measures are reported in Appendix D, Tables 4.11-4.28. The following chapter reports the significant findings in these tables. The reader is referred to Appendix D for the appropriate table entries from which critical tests were computed.

Problem 2

(1) Number of positive instances to solution (Table 4.11). The main effect for Concept Rule was significant ($F = 32.53$, 1/56).[10] The number of positive card choices to solution for the inclusive disjunctive rule was significantly greater than it was for the conjunctive rule. The mean for positive card choices was 1.5 and 4.8 for the conjunctive and disjunctive tasks respectively. The main effect for Saliency and the interaction were not significant.

(2) Number of negative instances to solution (Table 4.12). The Concept Rule x Saliency interaction was significant ($F = 4.84$, 1/56). The interaction was disordinal, with greater negative card choices being chosen for the inclusive disjunctive rule when shape ("high" salient) was irrelevant than when color ("low" salient) was irrelevant. The reverse was true for the conjunctive rule. The interaction is represented in Figure 4.1.

The relationship between the factors establishes the differential structure of the concept rules. The nature of the conjunctive rule suggests that the greatest amount of information can be obtained from positive instances. For the inclusive disjunctive rule, the reverse is true. In Figure 4.1 a "high" salient dimension in the irrelevant position for the inclusive disjunctive rule provided the greatest number of negative card choices to solution.

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[9]The first problem was considered a "warm-up," allowing S to become accustomed to the experimental task.

[10]The .05 critical region was adopted for testing the significance of experimental effects in this and in later analyses.

Mean Scores Fig. 4.1

	A_1	A_2
B_1	1.33	0.93
B_2	1.20	2.20

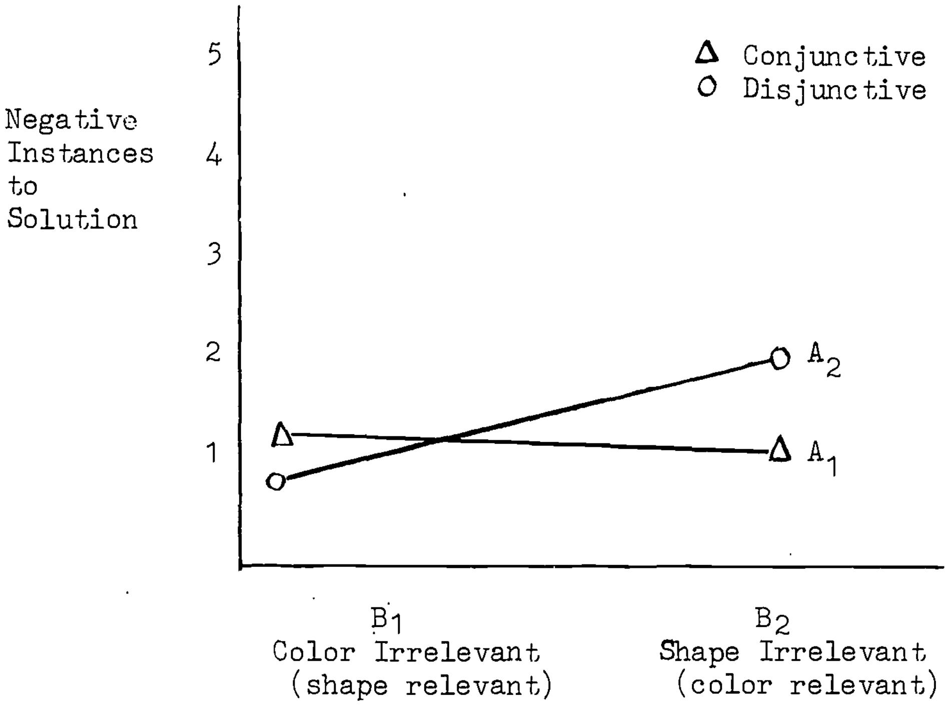

Fig. 4.1. Interaction of Saliency and Concept Rule. Problem 2, Negative Instances to Solution. A_1 vs. A_2 at B_2, $F = 8.77$, $F_{.99} = 7.64$ (1/28).

(3) <u>Total instances to solution</u> (Table 4.13). The concept rule main effect for the number of total trials to solution was also significant ($F = 19.23$, 1/56). Differences were in the predicted direction, with a mean of 2.7 for card choices to solution for the conjunctive rule, and a mean of 6.2 for the inclusive disjunctive rule. For the number of positive and the number of total card choices, the inclusive disjunctive rule was significantly more difficult than the conjunctive rule. As previously reported, however, no difference between these levels occurred in the number of negative instances to solution.

(4) <u>Time to solution</u> (Table 4.14). The concept rule main effect for time to solution was significant ($F = 17.89$, 1/56). As expected, time to solution was greater for the inclusive disjunctive than for the conjunctive rule. Mean time to solution for the conjunctive problem was 1 minute and 24 seconds, and for the inclusive disjunctive problem, 5 minutes and 3 seconds.

(5) <u>Focusing on the relevant dimension</u> (Table 4.15). The interaction of concept rule and saliency was significant and disordinal ($F = 6.78$, 1/48). The interaction is represented in Figure 4.2.

Mean Scores Fig. 4.2

	A_1	A_2
B_1	.39	.14
B_2	.15	.22

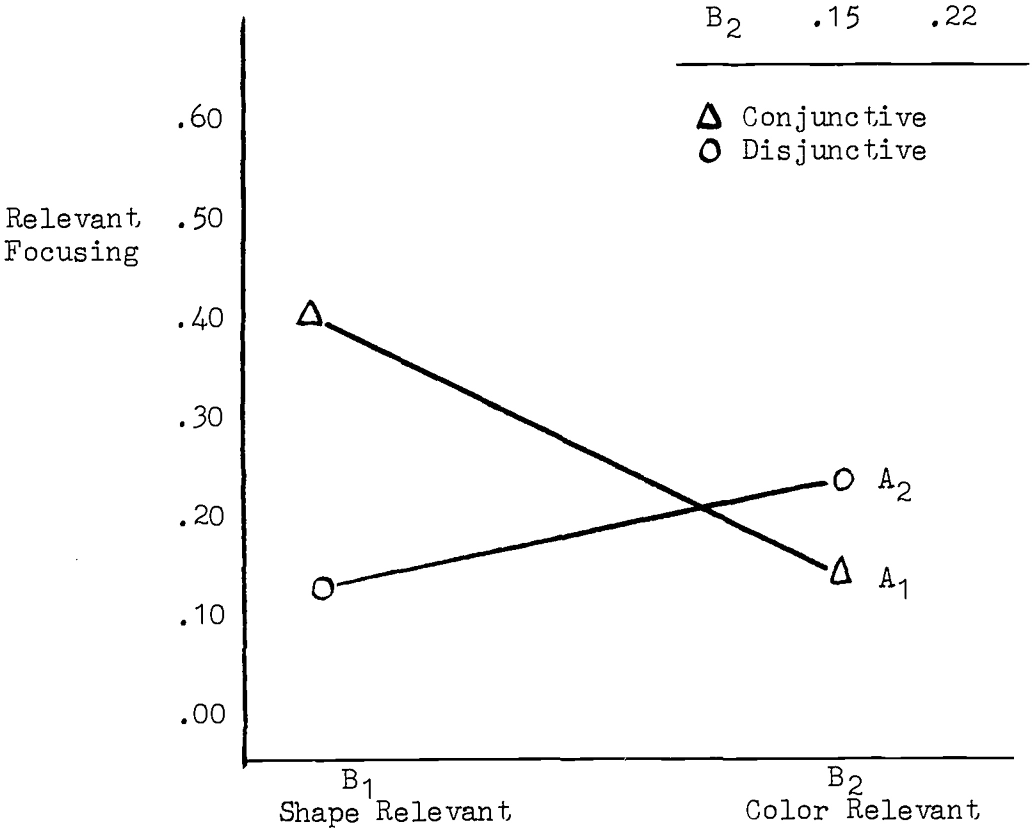

Fig. 4.2. Interaction of Concept Rule and Saliency. Problem 2, Relevant Focusing. A_1 vs. A_2 at B_1, $F = 9.67$, $F_{.99} = 7.64$ (1/28).

The interaction established a differential effect for saliency across concept rules. Greater relevant focusing for the disjunctive rule occurred for the color relevant "low" salient condition, while greater focusing for the conjunctive rule occurred for the shape relevant "high" salient condition. The difference between the shape and color relevant conditions for the conjunctive rule can be explained by the nature of the rule. If positive instances yield the greatest information in the conjunctive task, then a "high" salient dimension in the relevant position may be expected to increase focusing more than would a "low" salient dimension (A_1 at B_1). However, a "high" salient dimension in the relevant position for the disjunctive rule, where greatest information may be gained from negative instances, would not be expected to have the same effect (A_2 at B_1). In the experiment, optimal relevant focusing occurred for shape with the conjunctive rule, and for color with the disjunctive rule.

(6) Focusing on the irrelevant dimension (Table 4.16). The main effects for Concept Rule ($F = 6.00$, 1/56) and Saliency ($F = 4.08$, 1/56) were significant. The mean for irrelevant focusing in the conjunctive rule was .44 and in the inclusive disjunctive rule, .24.[11] The results indicated the reverse of what might be expected if Ss used more negative instances to solve the inclusive disjunctive rule than the conjunctive rule. However, the interaction reported for negative instances (Fig. 4.1) in the disjunctive rule indicated that when shape was irrelevant, Ss chose more negative instances than when color was irrelevant. The reverse was true for the conjunctive rule. Whereas the present main effect summed over saliency, the reported interaction indicated the differential effect of saliency. It is also important to note that the relationship between irrelevant focusing and negative instances to solution need not be perfect. S may choose an instance which is positive, while manipulating a dimension which is irrelevant.

For the saliency main effect, the mean irrelevant focusing scores for the shape-irrelevant ("high" salient) condition and for the color-irrelevant ("low" salient) condition were .42 and .26 respectively. As predicted, the higher mean focusing score occurred for the "high" salient dimension. These results may be summarized by indicating the percent to which mean focusing scores increased across conditions. Mean focusing

[11] A focusing score indicates the proportion of trials S has either focus gambled or conservatively focused.

was 62 percent greater for the shape-irrelevant condition than for the color-irrelevant condition and 45 percent greater for the conjunctive rule than for the inclusive disjunctive rule.

Results for dependent measures five and six, relevant and irrelevant focusing, can be summarized by juxtaposing the relevant and irrelevant mean focusing scores. The relationship between relevant and irrelevant mean focusing for the two saliency conditions can be seen in Table 4.1.

TABLE 4.1

Relevant and Irrelevant Focusing Scores for the Shape and Color Relevant Conditions Summing Across Concept Rules

Focusing	Shape relevant	Color relevant
Relevant	.27 (shape)	.19 (color)
Irrelevant	.26 (color)	.42 (shape)

When shape is relevant, the irrelevant dimension is color and vice versa. It can be noted, that for the color condition, the amount of irrelevant focusing on shape is greater than the amount of relevant focusing on color. A significant difference between levels for irrelevant focusing has already been reported.

Table 4.2 presents mean focusing scores for the conjunctive rule alone.

TABLE 4.2

Relevant and Irrelevant Focusing Scores for the Shape and Color Relevant Conditions, Conjunctive Rule

Focusing	Shape relevant	Color relevant
Relevant	.39 (shape)	.15 (color)
Irrelevant	.32 (color)	.55 (shape)

The difference between relevant and irrelevant focusing increased, but Table 4.2 indicates unusually strong mean focusing scores for the irrelevant dimension, especially when the "high" salient shape dimension was irrelevant. Positive instances, not negative, supposedly yield the greatest information for the conjunctive rule. However, irrelevant mean focusing increased from the disjunctive to the conjunctive rule. Moreover, the greatest mean focusing occurred for the "high" salient shape dimension, whether relevant or irrelevant (Tables 4.1 and 4.2). *Ex post facto* analyses will further explore these relationships.

Problem 3

(1) Number of positive instances to solution (Table 4.17). Two main effects and one interaction were significant. Levels of concept rule were significantly different; the inclusive disjunctive rule required significantly more positive instances to solution than did the conjunctive rule ($F = 28.03$, 1/48). The main effect for Stimulus Variety was also significant ($F = 5.72$, 2/48). Problem 3 used the form (△-○) and color pair for the intra-dimensional condition, the form (△-○) and borders pair for the inter-dimensional condition, and the form (L-S) and color pair for the control condition. The three means were submitted to a range test. Significant comparisons are reported in Table 4.3.[12]

TABLE 4.3

Significant Ranges for Levels of Stimulus Variety, Problem 3, Positive Instances to Solution

Means	1.80 Shape (L-S)/ Color	2.85 Shape (△-○)/ Color	3.30 Shape (△-○)/ Borders	Significant Ranges
1.80		1.05	1.50	$R_2 = .91$
2.85			0.45	$R_3 = .96$

Note.-Main effects underlined by a common line do not differ significantly from each other.

[12]The adjusted probability level is 90.2 when $k = 3$ or for this analysis $p < .10$. Therefore, the probability of a Type I error becomes slightly greater than when $p = .05$ and $k = 2$, while the probability of a Type II error decreases.

Differences between the form (Δ-O)/borders and form (L-S)/ color pairs, and between the form (L-S)/color and form (Δ-O)/ color pairs were significant.[13] For the interdimensional shift, significantly more positive instances were selected than for the control; and for the intradimensional shift, significantly more positive instances were selected than for the control. The order of difficulty reflected the magnitude of shift hypothesized for the intradimensional, interdimensional, and control conditions. Generally, the greater the shift, the more positive instances chosen before solution. In two of the three comparisons, this order of difficulty was established at or beyond the critical region of significance. The interaction between Stimulus Variety and Saliency was also significant ($F = 5.24$, 2/48). The interaction is presented in Figure 4.3.

Mean Scores for Fig. 4.3

	C_1	C_2	C_3
B_1	2.50	4.20	1.40
B_2	3.20	2.40	2.20

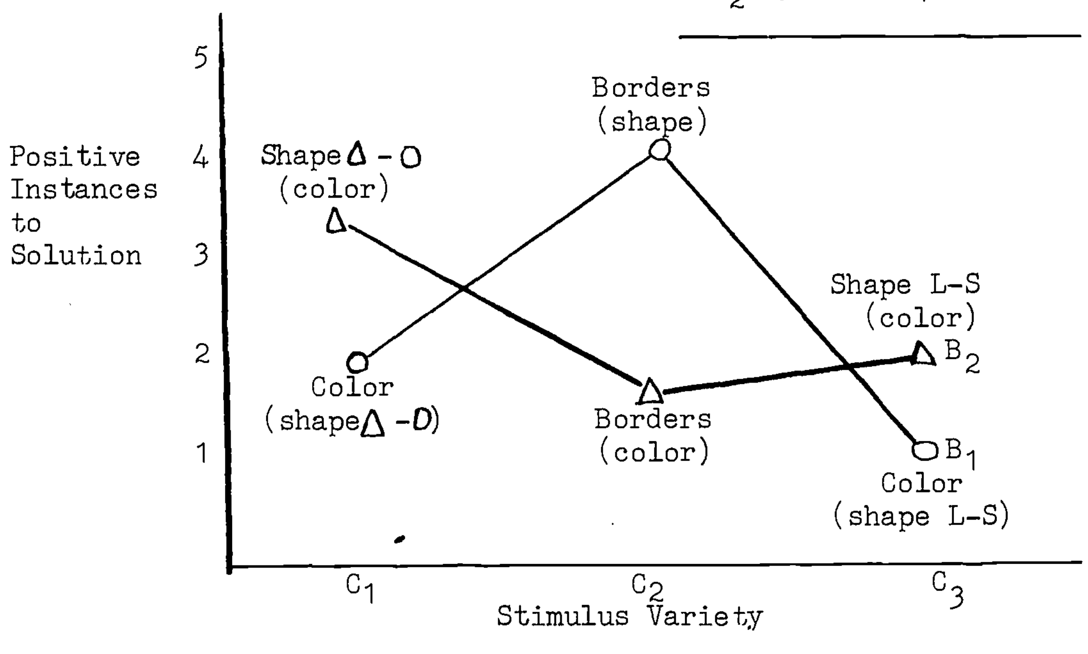

Fig. 4.3. Interaction of Stimulus Variety and Saliency. Problem 3, Positive Instances to Solution. Labelled Dimensions are Relevant. Irrelevant Dimensions are in Parentheses. B_1 vs. B_2 at C_2, $F = 7.83$, $F_{.97} = 5.92$ (1,18).

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[13]Significant comparisons reported here are viewed heuristically in light of a significant Concept Rule x Saliency interaction to be reported.

Levels of saliency varied across the stimulus variety conditions, in that Problem 3 was chosen to provide Ss with different stimulus dimensions for the intradimensional and interdimensional conditions. The greatest number of positive cards to solution for the shape relevant condition (B_2) occurred at C_1, the intradimensional shift, and at C_3, the control condition. At C_1 and C_3 the least number of positive instances occurred for the color relevant ("low" salient) condition (B_1). Although some difference can be noted between the form Δ-O (B_2 at C_1) and form L-S (B_2 at C_3) dimensions, their relation to the color relevant condition remains nearly identical, ($B_2 - B_1$ at $C_1 = 0.7$ and $B_2 - B_1$ at $C_3 = 0.8$). At C_1 and C_3, the lowest number of positive instances occurred for the "low" salient relevant dimension. The border dimension was relevant for both saliency conditions at C_2; however, for B_1 the form dimension was irrelevant, and for B_2 the color dimension was irrelevant. The difference between the two pairs was in accordance with research recorded in Chapter 2, which indicated the saliency of these dimensions. Borders and form represented dimensions for which preference was not significantly different, whereas borders and color represented dimensions for which preference was significantly different. The borders (B_2) dimension was highly preferred over the color dimension, whereas the border dimension and the form dimension (B_1) did not differ significantly. Therefore, few positive instances were noted for the "high" salient borders dimension in the relevant position when it was paired with the "low" salient color dimension in the irrelevant position.

(2) Number of negative instances to solution (Table 4.18). No significant effects were found.

(3) Total instances to solution (Table 4.19). The main effect for Concept Rule was significant ($F = 8.10$, 1/48). The mean for trials to solution for the conjunctive rule was 3.0 and for the inclusive disjunctive rule, 4.8. Levels differed in the direction predicted.

The Stimulus Variety x Saliency interaction was also significant ($F = 3.72$, 2/48). Differences between levels of stimuli across the saliency conditions paralleled those found for the interaction with positive instances to solution. The interaction is represented in Figure 4.4.

The magnitude, but not the direction, of the interaction changed from Figure 4.2 to Figure 4.4. For C_1 and C_3, differences between the saliency conditions were again similar ($B_2 - B_1$ at $C_1 = 0.7$, $B_2 - B_1$ at $C_2 = 0.4$). However, the difference between the borders and shape (B_1) and borders and colors (B_2)

pairs at C_2 increased from 1.8 to 3.1. This increase identified the mean for positive instances as a predictor of concept difficulty. Reducing the number of positive instances chosen, then, should increase task performance.

Mean Scores for Fig. 4.4

	C_1	C_2	C_3
B_1	3.70	6.20	2.90
B_2	4.40	3.10	3.30

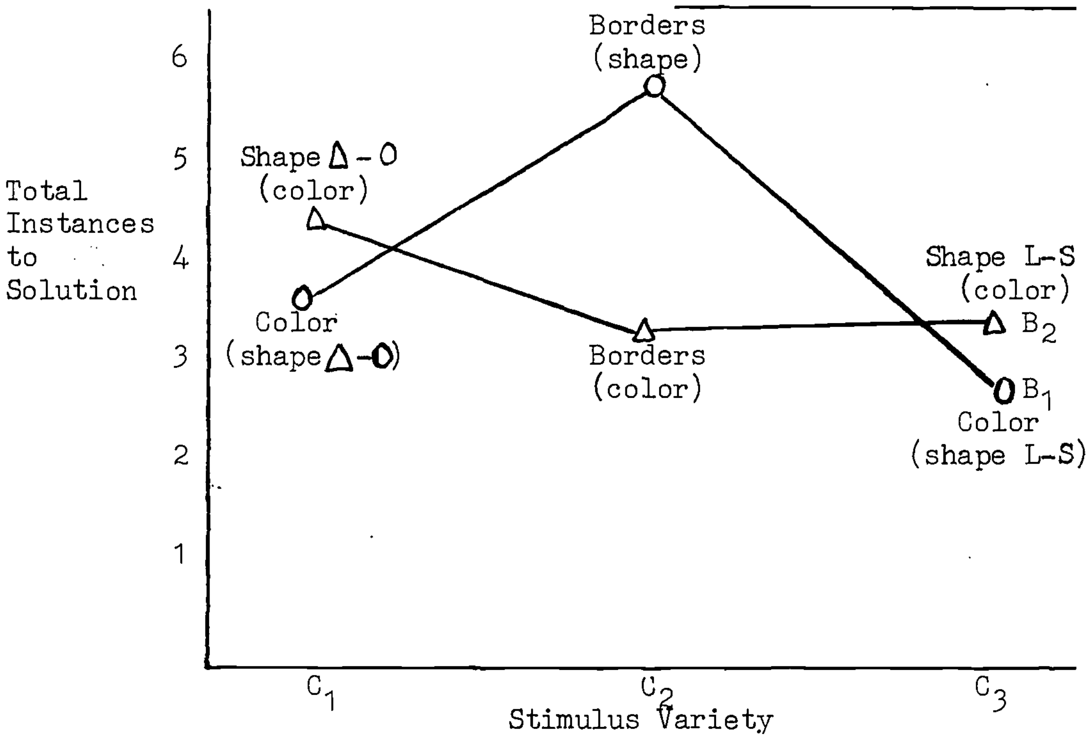

Fig. 4.4. Interaction of Stimulus Variety and Saliency. Problem 3, Total Instances to Solution. Labelled Dimensions are Relevant. Irrelevant Dimensions are in Parentheses. B_1 vs. B_2 at C_2, $F = 8.00$, $F_{.97} = 5.92$ (1/18).

(4) <u>Time to solution</u> (Table 4.20). The main effect for Concept Rule was significant and in the predicted direction ($F = 7.07$, 1/48). Time to solution for the conjunctive rule was 1 minute and 27 seconds and for the inclusive disjunctive rule, 4 minutes and 5 seconds.

(5) Focusing on the relevant dimension (Table 4.21). No significant effects were found.

(6) Focusing on the irrelevant dimension (Table 4.22). The main effect for Concept Rule was significant ($F = 16.05$, $1/48$). Irrelevant focusing for the conjunctive rule occurred on 47 percent of the trials, while for the inclusive disjunctive rule, irrelevant focusing occurred on only 15 percent of the trials. The direction of the difference was the opposite of what had been predicted, but was the same as it had been in Problem 2.

If the conjunctive rule can be solved most easily with positive instances, and the inclusive disjunctive rule most easily with negative instances, the irrelevant focusing scores should be greater for the disjunctive than for the conjunctive task. These results were submitted to ex post facto analyses to determine the relationships between irrelevant focusing scores, relevant focusing scores, and the total number of trials to solution.

The interaction between Concept Rule and Stimulus Variety was also significant ($F = 5.01$, $2/48$). The interaction is presented in Figure 4.5.

The strongest focusing for the conjunctive rule occurred for the intradimensional shift (C_1), in which Ss shifted from a form (L-S) and color pair in Problem 2 to a form (Δ-O) and color pair in Problem 3. The relationship was reversed and disordinal for the control condition, in which Ss were given the same dimensions as in Problem 2. The interaction, therefore, was a function of the control condition in relation to the intradimensional and interdimensional shift conditions. The height of A_1 at C_3 indicated the difficulty of focusing on the irrelevant dimension when the stimuli were form (L-S) and color, and the rule was conjunctive. It can be noted that the apparent subtle difference between triangle and circle at C_1, and the letters "L" and "S" at C_3, accounted for the interaction. Optimal focusing conditions were engendered for the conjunctive rule with form (Δ-O) and color, and form (Δ-O) and border stimuli, while optimal focusing for the inclusive disjunctive rule occurred for the shape (L-S) and color stimuli. The intradimensional shift or intermediate level of variety engendered the strongest irrelevant focusing for the conjunctive rule; the absence of a shift engendered the strongest focusing for the disjunctive rule.

Mean Scores for Fig. 4.5

	C_1	C_2	C_3
A_1	.60	.56	.20
A_2	.05	.11	.24

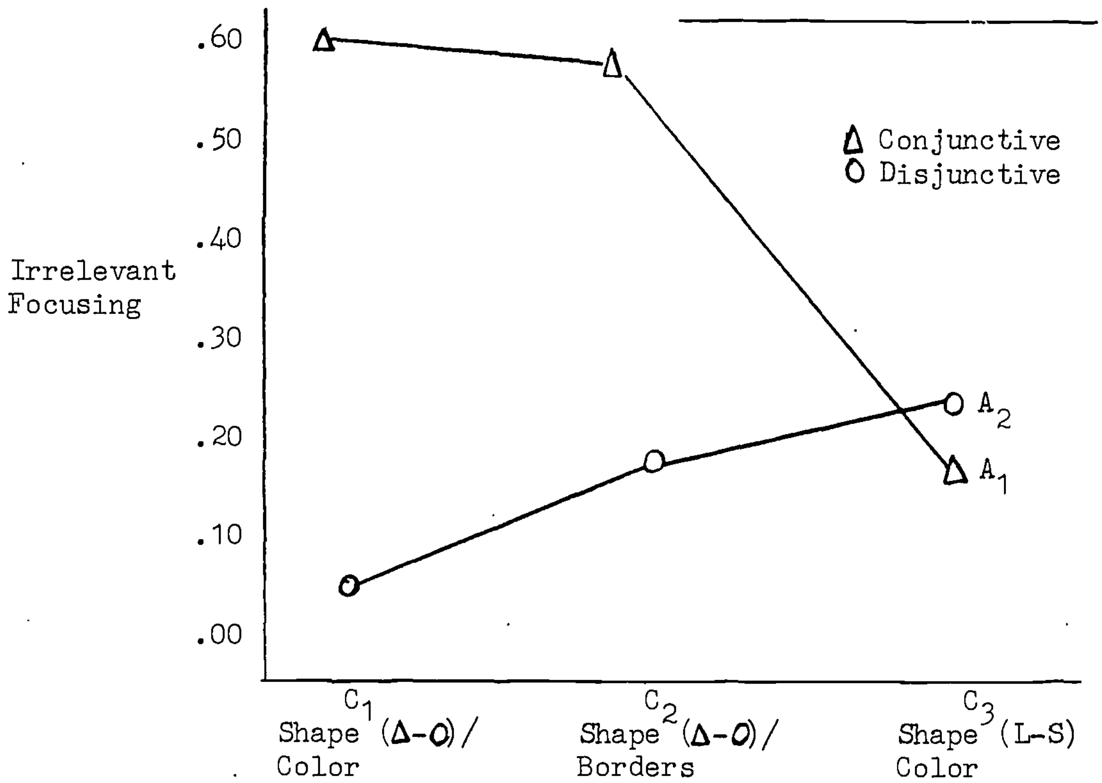

Fig. 4.5. Interaction of Stimulus Variety and Concept Rule. Problem 3, Irrelevant Focusing. A_1 vs. A_2 at C_1, $F = 15.30$, $F_{.99} = 8.28$ (1/18) A_1 vs. A_2 at C_2, $F = 10.80$, $F_{.99} = 8.28$ (1/18).

Problem 4

(1) Positive instances to solution (Table 4.23). The main effect for Concept Rule was significant and in the predicted direction ($F = 34.55$, 1/48). The mean number of positive instances for the conjunctive rule was 1.5 and for the inclusive disjunctive rule, 4.1. The significance and direction of this difference has been the same for all problems. The number of positive instances to solution may be taken as an index of concept rule difficulty.

(2) Negative instances to solution (Table 4.24). No significant effects were found.

(3) Total instances to solution (Table 4.25). The main effect for Concept Rule was significant ($F = 17.37$, $1/48$), as it has been for all problems. The relation between the rules was as expected. The conjunctive rule was solved in 2.7 trials and the inclusive disjunctive rule in 5.3 trials. For both rules, Problem 4 was neither the least nor the most difficult problem. This relationship may be seen in Table 4.4, by noting the mean number of trials to solution for each problem summed across the intradimensional, interdimensional, and control condition.[14]

TABLE 4.4

Mean Positive Instances to Solution for Concept Rule, Stimulus Variety and Problems

Problem	Conjunction				Disjunction			
	Intra	Inter	Control	$\bar{X}_t$	Intra	Inter	Control	$\bar{X}_t$
2	2.90	2.70	2.40	2.67	4.40	8.80	5.40	6.20
3	2.70	3.40	3.00	3.05	5.40	5.90	3.20	4.83
4	2.90	3.00	2.40	2.77	5.20	5.60	5.20	5.33
$\bar{X}_t$	2.83	3.05	2.61	2.83	5.00	6.76	4.60	5.45

While Problem 2, the training problem, appeared easiest for the conjunctive rule, it was the most difficult for the inclusive disjunctive rule. The reverse can be noted for Problem 3, the shift problem. Mean performance for the three levels of stimulus variety, summing across problems (down columns), indicated that, for both the conjunctive and inclusive disjunctive rules, most efficient solution occurred for the control condition, in which there was no shift in dimensions between problems 2 and 3. Note that the most efficient solution for Problem 2 of the conjunctive rule as well as

[14]Problems were not analyzed as a within factor due to the confounding effect the dimensional shifts (Problem 3) would have upon the fourth factor.

as Problem 3 of the disjunctive rule occurred for the control condition. These scores represented the lowest mean number of trials to solution for all the cells. Generally, then, the most efficient solution occurred for the concept rules when the solution, but not the stimulus values, were changed from problem to problem. The next most efficient solution occurred for the intradimensional shift condition, in which the values but not the dimensions were changed, and the least efficient solution occurred for the interdimensional shift condition, in which dimensions and values were changed. The conjunctive rule was solved most efficiently on the problem immediately following the "warm-up", while the disjunctive rule was solved most efficiently on the third problem, which also was the shift condition for two of the three S groups.

(4) Time to solution (Table 4.26). The main effect for Concept Rule was significant ($F = 12.37$, $1/48$) and in the same direction as analyses for Problem 2 and Problem 3. Time to solution for the conjunctive rule was 1 minute and 37 seconds, and for the inclusive disjunctive rule, 5 minutes and 31 seconds.

(5) Focusing on the relevant dimension (dots) (Table 4.27). The relevant dimensions for Problem 4 were both dots and interior lines. The correct solution required one value of dots (contiguous to the form or separate from it) and one value of interior lines (horizontal or vertical). Therefore, dependent measures five and six for Problem 4 were selected to assess focusing on the two dimensions, both of which were relevant. Dependent measure five analyzed focusing on the dot dimension, and dependent measure six analyzed focusing on the line dimension. No significant effects were found for dots.

(6) Focusing on the irrelevant dimension (lines) (Table 4.28). The main effect for Concept Rule was significant ($F = 7.47$, $1/48$). Ss focused on the line dimension on 40 percent of their trials during the conjunctive task and on 21 percent of their trials during the inclusive disjunctive task. Although no significant differences were found for the dot dimension, mean focusing on the line dimension was significantly greater for the conjunctive rule than for the disjunctive rule. For dots, 17 percent of the Ss' trials were devoted to focusing during the conjunctive task and 18 percent during the inclusive disjunctive task. The main effect differences found between dots (dependent measure five) and lines (dependent measure six) suggest, that for the conjunctive rule, the line dimension may be more salient than the dot dimension. However, the research reported in Chapter 2 found that lines and dots did not differ significantly in the saliency index used in this experiment. Both dimensions were relevant, and one can only suggest that during the conjunctive task Ss determined interior

lines as relevant before they discovered dots were also relevant. Ss were asked to voice their solution to the concept tasks after they were reasonably sure that they were aware of all the relevant values. Consequently, there is no way to determine if the greater mean focusing on lines under the conjunctive condition prompted that dimension to be determined first.

The main effect for Stimulus Variety was also significant ($F = 3.21$, 2/48). Mean line focusing for the intradimensional shift, interdimensional shift, and control condition was 23, 25, and 42 percent of the total trials to solution, respectively. Significant ranges were determined between the mean scores. They are presented in Table 4.5.

TABLE 4.5

Significant Ranges for Levels of Stimulus Variety, Problem 4, Line Focusing

Means	.23 Intra-shift	.25 Inter-shift	.42 Control	Significant Ranges
.23		.02	.19	$R_2 = .17$
.25			.17	$R_3 = .18$

Note.-Main effects underlined by a common line do not differ significantly from each other.

The control condition was significantly different from both the intradimensional shift and the interdimensional shift. Therefore, the less stimulus variety before transfer, the greater the focusing on the transfer task. Results coincided with those of Table 4.4, in which the greatest task efficiency for both conjunctive and disjunctive tasks occurred for the control or no shift condition. Stimulus variety in terms of intra- and interdimensional shifts did not enhance learning on a transfer task.

Ex Post Facto Analyses

Ex post facto analyses were undertaken to explore further the results of the formal analysis. Analyses have shown that the mean proportions of relevant and irrelevant focusing differed significantly in directions which were not predicted by the major hypotheses of this study. The hypothesis that mean irrelevant focusing is greatest for the inclusive disjunctive rule and that mean relevant focusing is greatest for the conjunctive rule has not been established. Therefore, the investigation failed to reject the null hypothesis. The results of analyses of dependent variable five, relevant focusing, and dependent variable six, irrelevant focusing, may be summarized by casting mean proportions for focusing and and problems in a common matrix. These proportions are presented in Table 4.6 as percent of focusing for the conjunctive and disjunctive rules.

TABLE 4.6

Difference in Percent Between Relevant and Irrelevant Focusing for Concept Rules and Problems

Problem	Conjunctive			Disjunctive		
	Rel.(R)	Irrel.(I)	I-R	Rel.(R)	Irrel.(I)	I-R
2	26.9	43.8	16.9	18.3	23.5	5.2
3	21.8	45.7	23.9	20.1	13.5	-6.6

The irrelevant differences minus the relevant differences remained consistent and high for the conjunctive rule as compared to the disjunctive rule. The amount of irrelevant focusing was greater than the amount of relevant focusing for the conjunctive task, but this relationship did not generalize to the disjunctive task.

Problem 2 was selected to ascertain the interrelationships between relevant focusing, irrelevant focusing, and the number of cards to solution. In Table 4.6 separate relationships were determined for the color relevant and shape relevant conditions. In Problem 2, all conditions utilized the color and shape dimensions, while in Problem 3, additional dimensions were introduced to provide levels of stimulus variety. By utilizing Problem 2 for the analysis, these levels were summed over for a total N of 15 in each saliency condition. The inter-correlations for mean relevant focusing, mean irrelevant focusing, and number of cards to solution are presented in Table 4.7. When relevant and irrelevant focusing were scored separately, focusing on the irrelevant dimension led to the quickest solution. The relationships for the disjunctive rule were not significant. Generally, one would have expected mean irrelevant focusing to produce a significant negative relationship with the number of trials to solution. The low focusing scores on dimensions in the disjunctive rule may have contributed to the different results across the two rules. Placing a "high" salient dimension in the relevant position for the conjunctive rule, where positive instances should have yielded the greatest information, did not enhance learning.

TABLE 4.7

Inter-Correlations for Cards-to-Solution (CTS), Relevant, and Irrelevant Focusing

Focusing	Conjunctive				Disjunctive			
	Color	Rel.	Shape	Rel.	Color	Rel.	Shape	Rel.
	CTS	Color	CTS	Shape	CTS	Color	CTS	Shape
Color	.58*		-.60*		-.30		.20	
Shape	-.50*	-.55*	.53*	-.83*	-.42	-.59*	-.29	-.24

*$p < .05$.

In order to assess whether saliency affected focusing, E determined the proportion of conjunctive Ss who were focusing on the "high" salient shape dimension and the "low" salient color dimension on the first trial of Problem 1 and Problem 2. The proportion of color and shape focusers across treatments and problems is indicated in Table 4.8.

TABLE 4.8

Number and Proportion of Shape and Color Focuses on First Trial, Conjunctive Rule

Focusing	Problem 1				Problem 2			
	Color	Rel.	Shape	Rel.	Color	Rel.	Shape	Rel.
	N	P	N	P	N	P	N	P
Shape	9	.60	8	.53	8	.53	7	.47
Color	4	.27	5	.33	4	.27	7	.47

The proportions of shape focusers for both conditions of Problem 1 plus the color condition of Problem 2 reveal that the majority of Ss were shape focusers on the first trial. Because of the significant correlation between irrelevant focusing scores and number of trials to solution, the proportion for the shape relevant condition of Problem 2 is expected. Ss might have learned to focus on the irrelevant dimension in Problem 1, and thus started Problem 2 on the assumption that the second problem would be similar to the first. The stimulus patterns and instructions for the two problems were identical. Moreover, all solutions were within a single dimension; that is, for the conjunctive rule the shape solution was "L" "L", while the color solution was "RED" "RED". Ss were solving Problem 1 most efficiently by focusing on the irrelevant dimension. Therefore, the decrease in the number of shape focusers for a shape relevant problem on trial one of the second problem is congruent with the relationship between irrelevant focusing and card choices to solution.

Although Table 4.8 indicates that the number of shape and color focusers on trial 1 was relatively stable across problems, this might not have been so for focusing within problems and across trials. Consequently, in order to determine major shifts, the proportion of color and shape focusers on the last trial was determined. Two hypotheses are suggested. The first is that color and shape focusing may be considered an aptitude invulnerable to change by type of concept or relevant dimension. Those Ss that begin focusing on a preferred dimension remain focusing on the dimension until a solution is reached. A second alternative suggests that, although preferences for one or the other dimension may exist in the population, the nature of the learning can modify the initial effects of preference. Proportions for shape and color focusing on the last trial across problems, which are presented in Table 4.9, support the latter alternative.

A comparison of cells across Tables 4.8 and 4.9 indicates a shift in the proportion of relevant focusers on the first and last trials. The proportion of irrelevant focusers from the first to the last trial remains relatively stable for the first and second condition of Problem 1 and the first condition of Problem 2. This stability may indicate that Ss representing the shift had, in the main, abandoned a focus strategy. The shape relevant condition of Problem 2 departs from the expected shift in that a low proportion of color focusers appears for the shape relevant condition in the last trial.

Backward learning curves were constructed for the data, but their interpretation differs somewhat from what is customary when learning is discontinuous, or when Ss have disproportionate numbers of trials. Figures 4.6-4.9 were constructed for the Solution (S), Solution minus 1 (S-1), and Solution minus 2 (S-2) trials.

TABLE 4.9

Number and Proportion of Shape and Color Focuses on Last Trial, Conjunctive Rule

	Problem 1				Problem 2			
Focusing	Color	Rel.	Shape	Rel.	Color	Rel.	Shape	Rel.
	N	P	N	P	N	P	N	P
Shape	8	.53	2	.13	9	.60	4	.27
Color	2	.13	6	.40	1	.07	3	.20

For each figure the proportion of irrelevant focusing peaked at the solution trial. The S-1 and S-2 trials indicated descending slopes for the irrelevant dimension and ascending slopes for the relevant dimension. Decreasing numbers of Ss were plotted at S-1 and S-2 trials, because the Ss who had already solved the problem had no S-1 or S-2 trial. As the shape and color lines approached or reached intersection, the proportion of shape to color focusers appeared similar, but, in effect, the irrelevant dimension focusers might have been solving the problem sooner. Thus, a smaller proportion was represented at the S-1 trial than at S, and a smaller proportion at S-2 than S-1. The change from the S to the S-1 trial was the most reliable index of shift.

Descending slopes or changes in proportions may not always indicate that shifts have occurred from one dimension to another. Ss may have chosen not to focus, or perhaps preferred to use some other strategy. Likewise, a focus for any given S on a trial may not indicate his true preference to focus. Few Ss focused on a single dimension for the duration of the task; most seemed to sample the available dimensions. Therefore, basing Ss' disposition to focus on a single trial increased the probability that a false positive occurred in Tables 4.8 and 4.9.

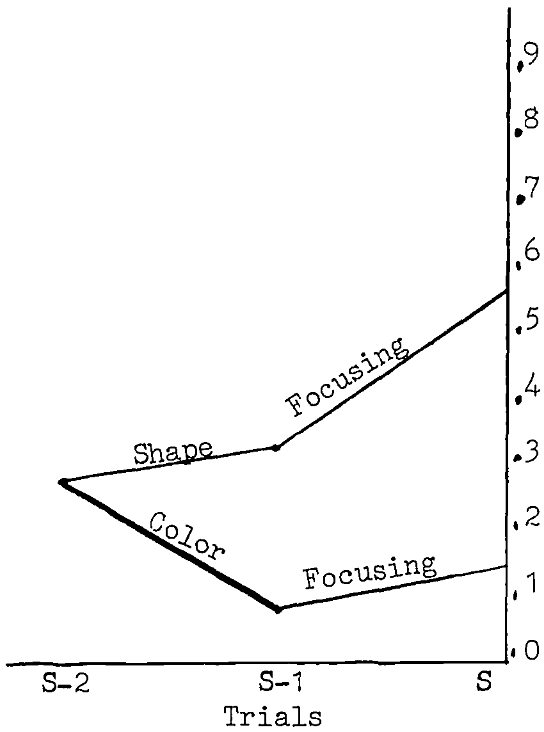

Fig. 4.6. Proportions of Color and Shape Focusing, Problem 1, Color Relevant.

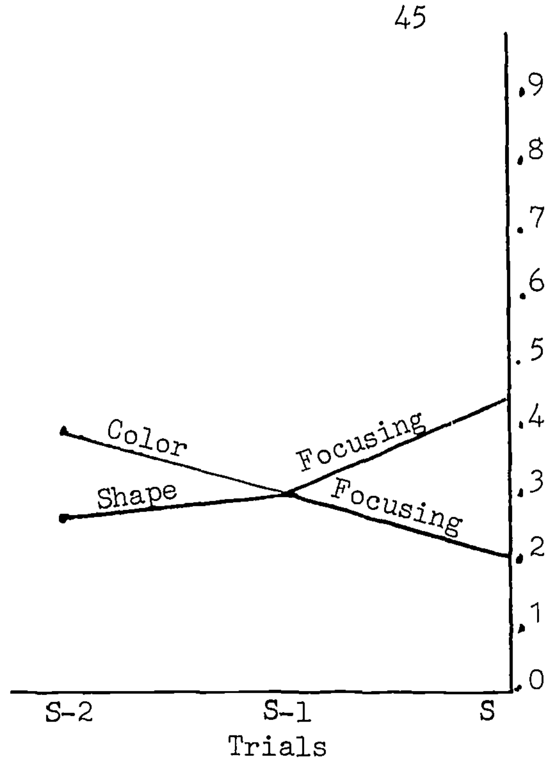

Fig. 4.7. Proportions of Color and Shape Focusing, Problem 1, Shape Relevant.

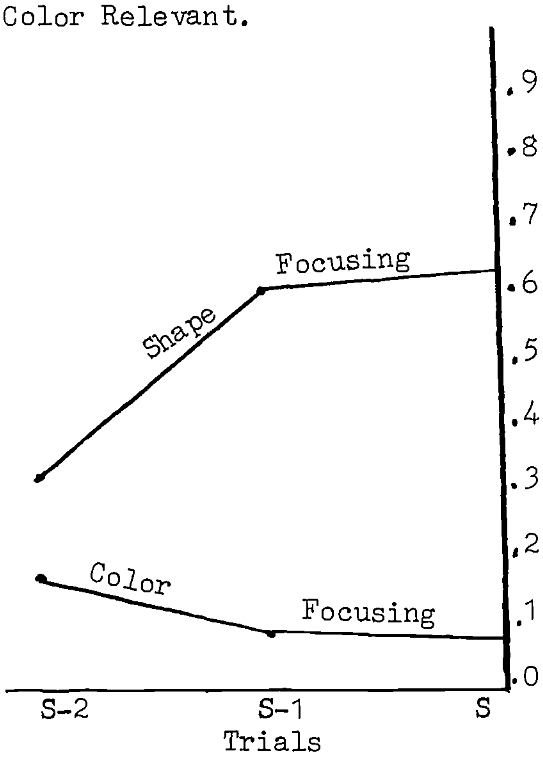

Fig. 4.8. Proportions of Color and Shape Focusing, Problem 2, Color Relevant.

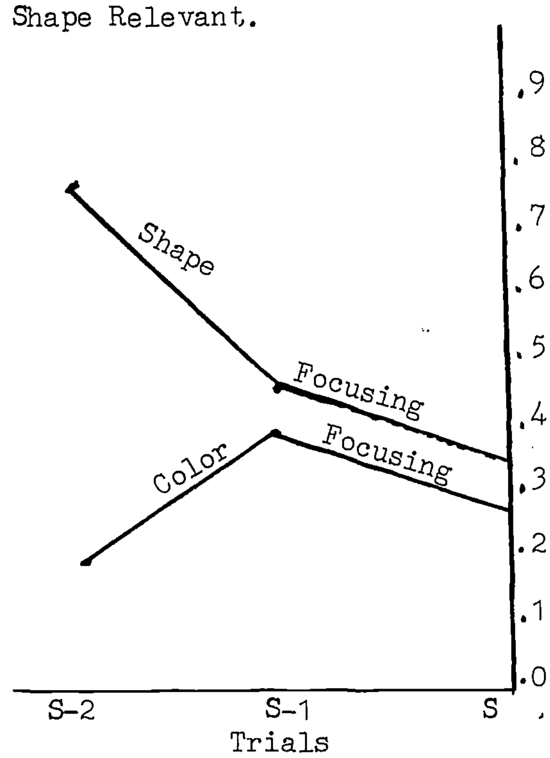

Fig. 4.9. Proportions of Color and Shape Focusing, Problem 2, Shape Relevant.

In order to determine if Ss were shifting from the relevant dimension, shape and color focusing scores for each S were subtracted and converted to a 0-100 scale, in which 100 represented shape focusing on every trial and 0 represented color focusing on every trial. Fifty indicated either the absence of focusing or focusing on color as much as shape. Correlations for the conjunctive rule between color and shape focusing were -.83 and -.55 for the shape and color conditions respectively. Therefore, focusing was considered unidimensional with shape at one pole and color at the other. Ss were divided into shape and color focusers on the basis of their focusing scores for all trials. Ss were classified as shape focusers if their shape minus color score (plus 1 times 50) equaled or exceeded 75. They were classified as color focusers if their shape minus color score equaled or was less than 25. Ss not focusing or focusing indiscriminately on shape and color were thereby eliminated from the calculations.[15]

The number of color and shape focuses for the first and last trials was determined for Ss classified as shape focusers (75 or greater) and color focusers (25 or less). These proportions for Problem 1 and Problem 2 appear in Table 4.10.

The results supported a switch hypothesis for Ss focusing on the relevant dimension. Irrelevant focusers on the first trial appeared to remain focusing on the irrelevant dimension until the last trial. The low proportion of color focusers reported in the Problem 2 shape relevant condition (Table 4.8) was not replicated for the present data. The hypothesis that Ss switch from the relevant dimension is supported across all conditions for both Problem 1 and Problem 2.

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[15]Before proceeding with the calculation of difference scores, scatterplots were examined for the linearity of color and shape focusing with the criterion. The scatterplots proved to be linear. Next, slopes for the difference scores across treatments were computed, and it was found that their absolute values were nearly identical (shape relevant slope = 1.21; color relevant slope = -1.21). The reliability of the difference score may be determined from computations by Gulliksen (1950) and Lord (1963) when the variance of the errors of measurement is known or can be estimated. It is important to note that the difference between errors of measurement for color and shape focusing should be at a minimum, in that both measures will be derived from the same task and will not correspond to the traditional post minus pre paradigm.

TABLE 4.10

Proportion of $\underline{S}$s Categorized as Color, Shape, and Neither, Focusing Within Their Category on the First and Last Trial

	Problem 1				Problem 2			
Focuser	Color	Rel.	Shape	Rel.	Color	Rel.	Shape	Rel.
	First	Last	First	Last	First	Last	First	Last
Shape (75)	1.00	1.00	1.00	.33	1.00	.86	.86	.29
Color (25)	1.00	.00	.80	.60	1.00	.00	1.00	.60
Neither (26-74)	.20	.40	.29	.43	.43	.43	.00	.33

Lastly, the difference in the regression slopes of the shape and color focusing scores for the shape relevant and color relevant conditions was tested for significance. The relationship between focusing and the criterion for the color relevant and shape relevant conditions was determined by calculating the $\underline{y}$ intercepts and regression slopes across each condition. The relationships of these slopes to one another appear as response surfaces in three-dimensional space in Figure 4.10.

If we consider shape and color focusing as ability measures Figure 4.10 suggests the presence of an aptitude by treatment interaction. The following discussion attempts to determine the significance of this interaction.

Examining the aptitude by treatment interaction. Walker and Lev (1953) and Edwards (1968) illustrate a method for testing the homogeneity of group regressions for the case in which there is one predictor. Studies which have investigated aptitude-treatment interactions (see Cronbach and Snow, 1969) have adopted the homogeneity of regressions test as standard methodology for assessing the difference in regression slopes across treatments. The statistical model for this test, however, is inappropriate for the case in which there are two or more aptitude variables. Therefore an attempt is made here to illustrate a method for testing the aptitude (color, form focusing) treatment (color relevant, form relevant) interaction. Appropriate methodology will be reviewed and applied to the data.

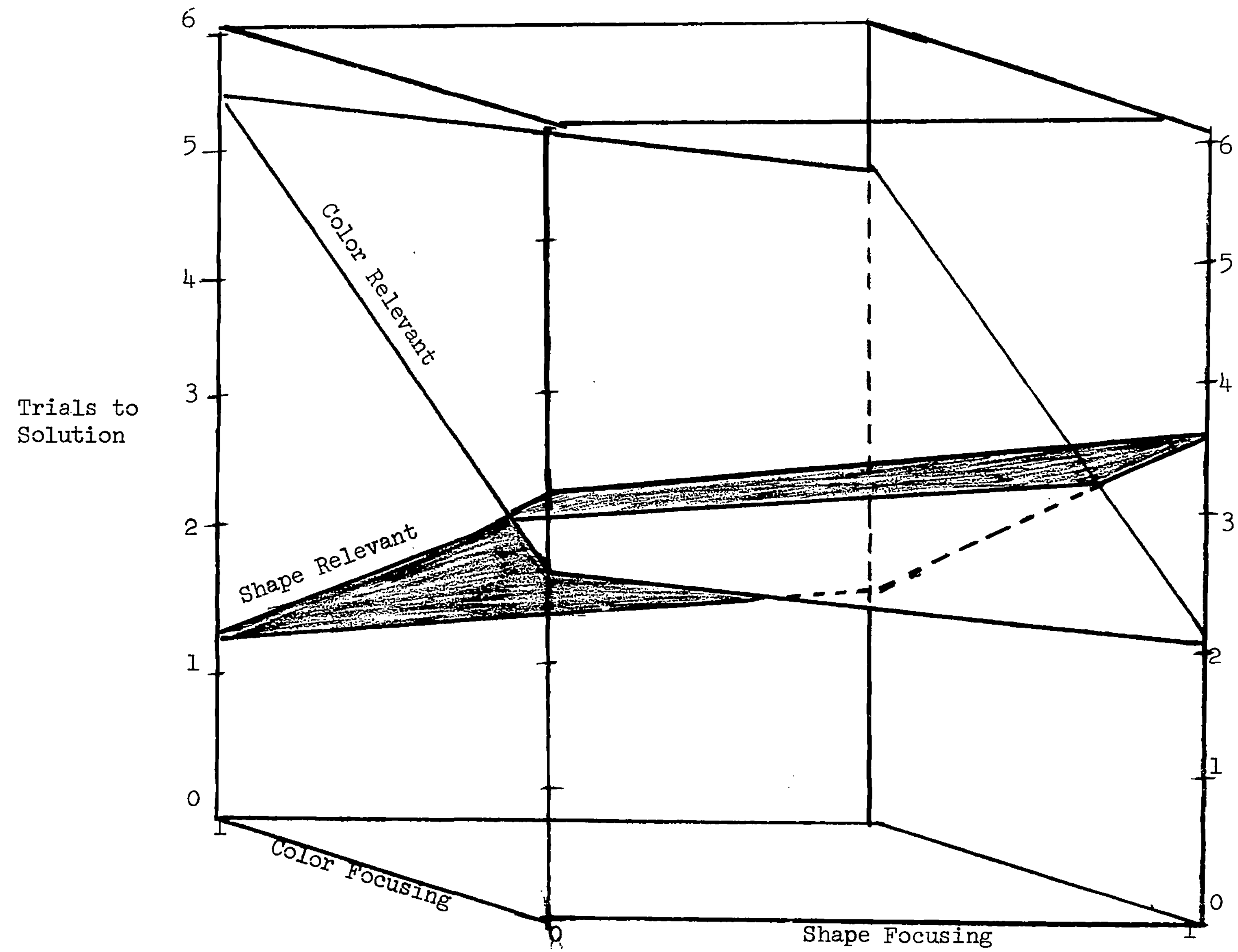

Fig. 4.10. Color Relevant and Shape Relevant Response Surfaces with Color and Shape Focusing as Predictors. Shape Relevant: $y' = 3.05 + (-1.81c) + .50s$. Color Relevant: $y' + 2.63 + 2.82c + (-.59s)$.

The analysis of covariance model. The homogeneity of group regressions test may be familiar to the reader as the test which precedes analysis of covariance. The purpose of the test is to determine whether or not regressions of the dependent measure on the covariate differ significantly across treatments. An underlying assumption of analysis of covariance is not met when regressions significantly differ.

The homogeneity of regression lines test (Walker and Lev, 1953; Edwards, 1968) is performed with one covariate and one criterion for multiple treatment groups. The F ratio for the homogeneity of regression lines test is derived from the variation of two sources: (a) observations within each treatment group about the regression for the groups, and (b) observations within each treatment group about the regression lines with a common slope. The error term is represented by (a), while the difference between (a) and (b) represents the treatment variation. A brief review of the homogeneity of regression lines test will be used to illustrate the general model. After which, we shall extend the model to test for homogeneity of regressions when multiple covariates are present.[16]

Homogeneity of group regressions, single covariate. To test the hypothesis that $B_1 = B_2 = \ldots = B_k = B$ (i.e. the slopes are equal), we start with the standard linear prediction model:

$$Y_{ij} = a_j + B_j X_{ij} + e_{ij};\ j = 1 \ldots, k;\ i = 1, \ldots, n_j$$

where Y_{ij} is the criterion, a_j is the intercept of the j^{th} group, B_j is the slope in the j^{th} group, X_{ij} is the covariate, k is the number of groups, and n_j is the number of subjects in the j^{th} group.

The residual sum of squares (i.e., $\Sigma \hat{e}^2_{ij}$) has degrees of freedom given by the number of subjects minus the number of parameters fit. Therefore, we have N-2k degrees of freedom.

To test that $B_1 = B_2 = \ldots = B_k = B$ we next fit the data to a second more restrictive model (observations within each treatment group about the regression lines with a common slope) given by:

$$Y_{ij} = a_j + BX_j = f_{ij};\ j = 1, \ldots, k;\ i = 1, \ldots, n_j$$

[16]While analysis of covariance can be performed with various computer programs, these programs do not commonly test for homogeneity of regressions. Multiple regression programs, including BMD03R, however, may be used to obtain the quantities specified below.

For the residual sum of squares ($\Sigma\hat{f}^2_{ij}$) we have N-k-1 degrees of freedom.

Since the restricted model combines treatment groups, we expect $\Sigma\hat{f}^2_{ij}$ to be greater than $\Sigma\hat{e}^2_{ij}$. These can be equal if the hypothesis is true, but $\Sigma\hat{f}^2_{ij}$ can not be less than $\Sigma\hat{e}^2_{ij}$.

To test for equal slopes, we form a hypothesis sum of squares given by $SS_{hyp} = \Sigma\hat{f}^2_{ij} - \Sigma\hat{e}^2_{ij}$ with (N-k-1) - (N-2k) = k-1 degrees of freedom. An F test can then be formed utilizing observations within each group about the regression for the group as an estimate of error:

$$F\ (k-1,\ N-2k) = \frac{SS_{hyp}\ /\ (k-1)}{\Sigma\hat{e}^2_{ij}\ /\ (N-2k)}$$

To the extent that covariates are unrelated (r = .00) in multiple covariate problems there is justification for performing the homogeneity of regression lines test separately for each covariate. When such a relationship is not obtained, we must take into account the relation between covariates. Other models in which a null relationship between covariates is not assumed are more generally applicable to multiple covariate problems.

Homogeneity of group regressions, multiple covariates. For the case in which there are multiple covariates, a test between hyper-planes is analogous to the Walker and Lev and Edwards test of regression lines. A test for homogeneity of regressions with multiple covariates provides an overall estimate of the difference between treatments, taking into account the effect of the multiple covariates upon each treatment simultaneously. The error term for such a test is given by the summed residual sum of squares for treatments, while the treatment variation is given by the summed residual sum of squares for treatments minus the residual sum of squares for the treatment groups combined.

If we have n number of covariates, $X_1, X_2, \ldots, X_n$, our full model becomes:

$$Y_{ij} = a_j + B_{1j}X_{1ij} + B_{2j}X_{2ij} +, \ldots, B_{nj}X_{nij} + e_{ij}$$

with N-pk degrees of freedom, where p equals the number of parameters fit.

Constructing the restricted model for multiple covariates we have:

$$Y_{ij} = a_j + B_1X_{1ij} + B_2X_{2ij} +, \ldots, B_nX_{nij}f_{ij}$$

with N-k-(p-1) degrees of freedom, where p-1 equals the number of covariates.

The sum of squares for the hypothesis of equal slopes is given by

$$SS_{hyp} = \Sigma\hat{f}^2_{ij} - \Sigma\hat{e}^2_{ij}$$

which has N-k-(p-1) - (N-pk) = p(k-1) + 1-k degrees of freedom.

The F test, again utilizing observations within each group about the regression for the group as an estimate of error, is given by

$$F\ p(k-1) + 1-k,\ (N-pk) = \frac{SS_{hyp}\ /\ p(k-1) + 1-k}{\Sigma\hat{e}^2_{ij}\ /\ (N-pk)}$$

The homogeneity of regressions test with multiple covariates measures the overall treatment effect but does not indicate differences in the regressions which may be due to any one covariate. The result, therefore, is a generalized test which determines the significance of the treatment variation but not the separate effect of the covariates upon the treatment variation.

Partial hypotheses for the multiple covariate model. In order to isolate the cause of the overall interaction we can construct partial hypotheses based upon the restricted model. Here, we make no assumptions of uncorrelated covariates as would be the case if the regression lines test were applied. To form partial hypotheses we construct the model:

$$Y_{ij} = a_j + B_1X_{1ij} + B_{2j}X_{2ij} + B_{nj}X_{nij} + g_{ij}$$

in which treatments are combined for one covariate and allowed to differ for the remaining covariates. For the partial hypothesis sum of squares we have $\Sigma\hat{g}^2_{ij} - \Sigma\hat{e}^2_{ij}$ with N-k(p-1)-1-(N-pk) = (k-1) degrees of freedom. The F test for this hypothesis is given by

$$F(k-1,\ N-pk) = \frac{SS_{hyp}\ /\ (k-1)}{\Sigma\hat{e}^2_{ij}\ /\ (N-pk)}$$

Partial hypotheses are constructed for each covariate to identify the causes of the interaction. For each covariate tested, a common slope is formed, while slopes for all other covariates are allowed to differ by treatment.

Testing the full and partial hypotheses. For the data represented in Fig. 4.10, we have,

$$\text{Homogeneity of Multiple Regressions (full hypothesis)} = \frac{43.96 - (16.76 + 12.07)/2}{16.76 + 12.07/(15 + 15 - 6)} = 6.30 \text{ (df 2, 24)}$$

which is significant at $p < .01$.

Treatment differences for each covariate may be determined with partial hypotheses (i.e. $B_{1j} = B_1$). To isolate the cause of the interactions we construct all possible partial hypotheses.

$$B_1 = B_{1j} \quad (B_{2j}\text{'s Differ})$$
$$B_2 = B_{2j} \quad (B_{1j}\text{'s Differ})$$

and construct the restricted models:

$Y_{ij} = a_j + B_1X_{1ij} + B_{2j}X_{2ij} + g_{ij}$ (to test $B_1 = B_{1j}$) with df given by $N - k - 1 - k = N - 2k - 1$, and

$Y_{ij} = a_j + B_{1j}X_{1ij} + B_2X_{2ij} + g_{ij}$ (to test $B_2 = B_{2j}$) with df given by $N - k - k - 1 = N - 2k - 1$, with the full model given by:

$$Y_{ij} - a_j + B_{1j}X_{1ij} + B_{2j}X_{2ij} + e_{ij}$$
with $N - k - k - k = N - 3k$ degrees of freedom.

In order to calculate F ratios for the partial hypotheses, treatments are dummy coded either before or after the test of the full hypothesis. In either case the error sum of squares for the full and restricted models and their degrees of freedom will be identical. To dummy code the data we create six new vectors:

T_1 = vector, of dimension n, in which the element is 1 if the corresponding y' value belongs to treatment 1; and 0 if otherwise.

T_2 = vector, of dimension n, in which element is 1 if the corresponding y value belongs to treatment 2; and 0 if otherwise.

T_1X_1 = product vector, of dimension n, which has as elements the first aptitude scores for treatment 1; 0's for treatment 2.

T_2X_1 = product vector, of dimension n, which has as elements the first aptitude scores for treatment 2; 0's for treatment 1.

T_1X_2 = product vector, of dimension n, which has as elements the second aptitude scores for treatment 1; 0's for treatment 2.

T_2X_2 = product vector, of dimension n, which has as elements the second aptitude scores for treatment 2; 0's for treatment 1.

With the new vectors the full model for testing the overall difference in regression planes is given by:

$$y = T_1 + T_2 + T_1X_1 + T_2X_1 + T_1X_2 + T_2X_2 + e$$

While, the restricted model for the overall test is given by:

$$y = a + (T_1X_1 + T_2X_1) + (T_1X_2 + T_2X_2) + e$$

where a = the unit vector.

For the partial hypothesis $B_1 = B_{1j}$ we construct the restricted model

$$y' = (T_1X_1 + T_2X_1) + T_1X_2 + T_2X_2 + e$$

and for the partial hypothesis $B_2 = B_{2j}$:

$$y' = T_1X_1 + T_2X_1 + (T_1X_2 + T_2X_2) + e$$

with degrees of freedom identical to those determined from the uncoded data. Further examples of dummy and contrast codes are provided by Cohen (1968), Bottenberg and Ward (1963) and Hamilton (1969).

For the partial hypotheses in Fig. 4.10 we have:

$$\underset{\text{(Aptitude A)}}{\text{Hyp}_{B_1} = B_{1j}} = \frac{38.61 - 28.83/1}{28.83/24} = 9.78 \text{ (df, 1, 24) } p<.01$$

$$\underset{\text{(Aptitude B)}}{\text{Hyp}_{B_2} = B_{2j}} = \frac{37.73 - 28.83/1}{28.83/24} = 7.42 \text{ (df, 1, 24) } p<.01$$

Both aptitudes, therefore, significantly contribute to the overall interaction.

<u>Examining the interaction with combined aptitudes</u>. Another estimate of the aptitude variables was obtained by constructing a combined focusing score. Color and shape focusing converted to a 0-100 scale, in which 100 represented perfect shape focusing and 0 perfect color focusing, provided the raw data for two simple linear regressions, one for the shape relevant condition and one for the color relevant condition. These equations are illus-

trated in Figure 4.11. A dotted line indicates the point at which the two regressions intercept one another.

The intercept occurred at a focusing score of 62.5. Any S whose score was above the intercept performed most efficiently in the "color relevant" condition, and any S whose score was below it performed most efficiently in a "shape relevant" condition.[17] The exact region of significance was determined with the Neyman-Johnson technique (Walker and Lev, 1953). Thus, if one treatment would cost more than the other, as color displays may, a region could be determined at the .05 level of confidence in which S would perform significantly better with the assigned treatment. Solid lines indicated the regions of significance for this data. Regions increase as N becomes larger and as the regression slopes increase. The difference between the regression slopes for Figure 4.11 was significant beyond the .001 level of confidence.

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[17]Scatterplots confirmed that Ss were distributed along the entire length of each regression line.

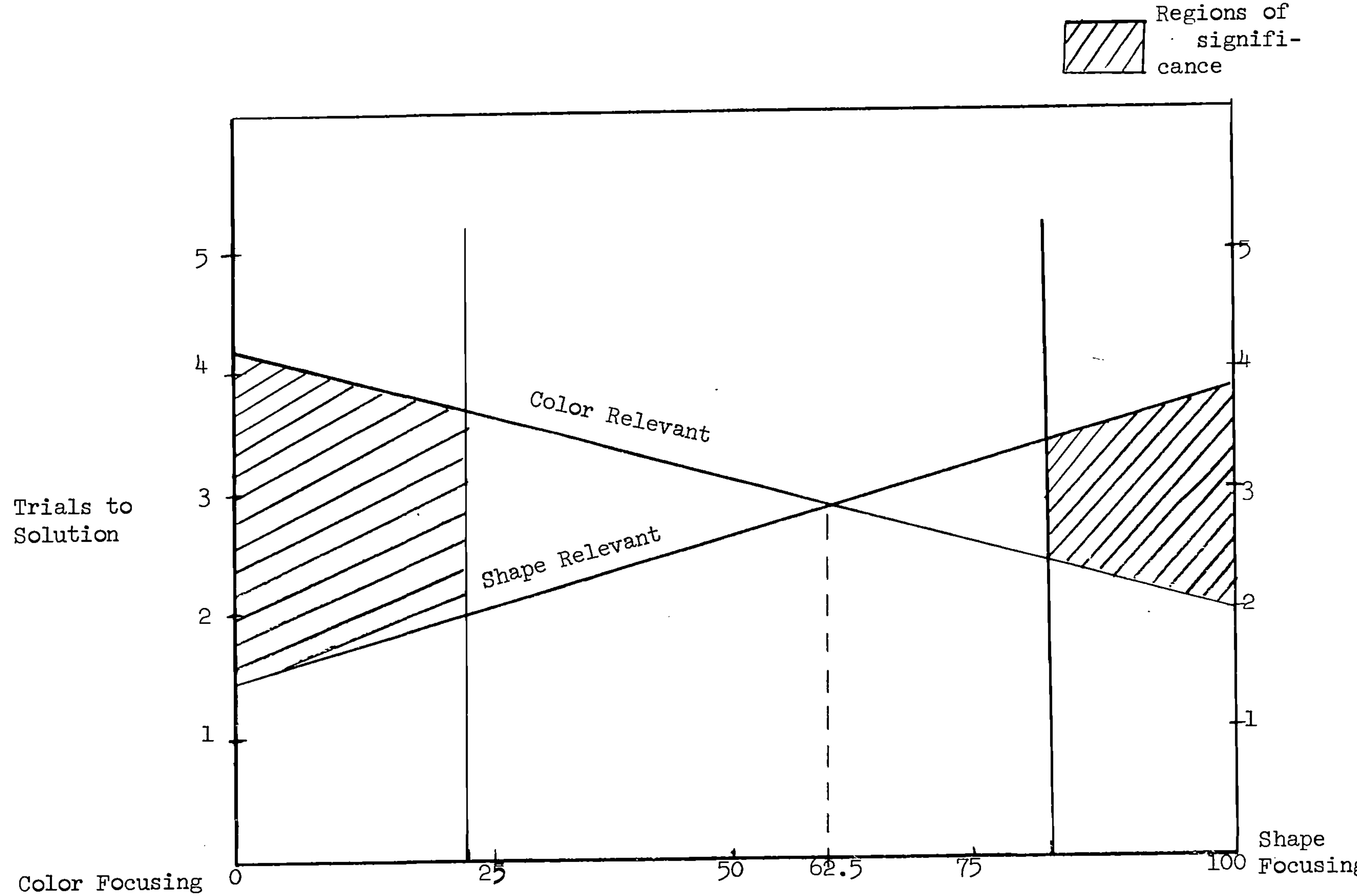

Fig. 4.11. Regressions for Color Relevant and Shape Relevant Treatments with Unidimensional Focusing As a Predictor. Shape Relevant: $y' = 1.38 + 1.21x$. Color Relevant: $y' = 4.39 + (-1.20x)$.

Chapter 5

Discussion and Conclusions

Concept Rule

The obtained result that the conjunctive rule was less difficult than the inclusive disjunctive rule, supported experimental hypothesis 1. Although Conant and Trabasso (1964), and Haygood and Bourne (1965) used several dimensions and values which were different from the present study, there is agreement between their findings and those of the writer as to the relative difficulty of the concept rules. This research departs from that of others in that it has studied the relative difficulty of concept rules with several newly constructed dependent measures. These measures may be identified as number of positive trials to solution, number of negative trials to solution, time to solution, and relevant and irrelevant focusing scores. The order of difficulty for the number of total trials to solution was identical to the order of difficulty for the number of positive trials to solution and the time to solution.

The number of negative trials to solution does not appear to be an index of concept difficulty. This finding is of special significance for the conjunctive rule, in that optimal performance may be engendered by devising treatments which reduce the number of positive, but not negative trials to solution. For the inclusive disjunctive rule, negative trials to solution were expected to increase task performance, and thereby relate negatively to total trials to solution. However, negative instances were not significantly different between rules, and it may be concluded that the inclusive disjunctive rule, in itself, does not encourage S to select more negative instances than he would when performing a conjunctive task.

Strength of irrelevant focusing was also significantly different between concept rules. Contrary to logical predictions, the amount of irrelevant focusing was greater for the conjunctive task than for the inclusive disjunctive task. This finding suggests that basic assumptions about the nature of these concept rules in two dimensional problems, in which one dimension is relevant, may be subject to revision. In that this study has been the first to score relevant and irrelevant focusing separately, it may be the first to report that the amount of irrelevant focusing is significantly greater for the conjunctive than for the inclusive disjunctive rule. Ex post facto analyses have been used to explain irrelevant focusing and its relation to total number of trials to solution for the conjunctive rule.

Saliency

The obtained result that no main effects occurred for positive trials to solution, negative trials to solution, total trials to solution, or time to solution supported experimental hypothesis 2. If significant interactions were predicted between Concept Rule and Saliency, summing across concept rules should not have indicated a significant difference between levels of saliency. The obtained result, that irrelevant focusing was significantly different for the shape ("high" salient) and color ("low" salient) dimensions, indicated that saliency is related to focusing when irrelevant dimensions are studied. This result failed to reflect a predicted interaction between Concept Rule and Saliency for irrelevant focusing scores. However, the result did indicate that the saliency estimates used for this study did engender experimental results in predictable directions. A "high" salient dimension produced higher focusing scores than a "low" salient dimension. For this finding, results were confined to irrelevant focusing. No significant differences were found between these dimensions for relevant focusing. If irrelevant focusing does indeed assist efficient concept solution, "high" salient dimensions may be employed to increase focusing.

Stimulus Variety

The obtained result that transfer was not a function of stimulus variety, failed to support experimental hypothesis 3. No significant differences were reported for total number of trials to solution between levels of stimulus variety on the transfer problem. Stimulus variety conditions, however, did significantly effect line focusing on the transfer problem. Strength of focusing on lines, one of two relevant dimensions, was significantly greater for the control condition than for the intradimensional and interdimensional shift conditions. These data suggest that focusing may be strengthened on transfer problems by creating a minimum level of variety, in which the solution, but not the dimensions or values, change prior to transfer. Increasing the variety of stimuli may distract S from solving the problem in a consistent manner. The effect of presenting S with new values and dimensions prior to a transfer task may, in the case of focusing, disrupt the process by which S learns that the greatest information gain is derived from focusing. New values and dimensions may induce a novelty effect that is detrimental to focusing. Levels of variety, however, did not produce sufficient systematic variance in the number of trials to solution to consider the treatments significantly different. Heuristically, it is important to note that although levels were not significantly different, learning was most efficient for the control or no variety condition, next most efficient for the intradimensional variety condition, and least efficient for the interdimensional or greatest variety condition. The stimulus variety conditions may not have led to greater transfer because the experimental conditions in this study did not meet the optimal conditions set forth in Morrisett and Hovland's (1959) research. The present study emphasized generalization, but did not, perhaps, provide an opportunity for each problem to be learned sufficiently before a shift was introduced. Morrisett and Hovland suggest such an interpretation when, at the conclusion of their research, they report that a high degree of learning within one problem is a more important determiner of transfer than breadth of experience with different examples of the concept.

Concept x Saliency

A Concept Rule x Saliency interaction for positive card choices to solution was not obtained, and experimental hypothesis 4 was not supported. Placing shape rather than color in the relevant position for the conjunctive rule did not significantly improve learning, nor did placing shape in the irrelevant dimension for the inclusive disjunctive rule. Several interactions between Concept Rule and Saliency did occur. More negative instances were chosen for the disjunctive rule when shape was irrelevant (rather than relevant) and for the conjunctive rule when color was irrelevant (rather than relevant). For the disjunctive rule, results were as expected, in that a "high" salient irrelevant dimension induced greater negative instances than did a "low" salient irrelevant dimension. This relationship should have produced (but did not) a more efficient solution for the shape irrelevant condition than for the color irrelevant condition in the disjunctive rule. For the conjunctive rule, however, greater negative instances were chosen for the color irrelevant than for the shape irrelevant condition. In order to support the hypothesis, the direction of the discrepancy between negative and positive instances should have been reversed. When shape was irrelevant for the conjunctive rule more, not fewer, negative cards should have been chosen than had been when color was irrelevant. The results, however, indicate that the greatest number of negative instances occurred when shape was irrelevant for the disjunctive rule (predicted) and when color was irrelevant for the conjunctive rule (not predicted).

It can be concluded that the present analysis supports the hypothesis that placing a "high" salient dimension in the irrelevant position for the inclusive disjunctive rule increases the number of negative instances selected, thereby allowing S to derive maximum information.

The interactive effects of shape and color upon concept rule were also significant for relevant focusing. The greatest amount of focusing occurred when shape was relevant for the conjunctive rule and when color was relevant for the disjunctive rule. The results obtained supported hypothesis 4 for the relevant focusing measure. As predicted, the greatest amount of relevant focusing occurred for the "high" salient dimension in the conjunctive rule, where positive instances yielded the greatest information. However, for the disjunctive rule color, not shape, appeared most salient and was the dimension for which most relevant focusing occurred.

As in the previous interaction, it appears that while shape may be considered "high" salient for the conjunctive rule, this may not be so for the inclusive disjunctive rule. This finding expands the work of Trabasso and Bower (1968), which determined the effect of saliency with concept rules employing relevant redundant cues only.

Concept Rule x Stimulus Variety

Although the experimental hypotheses did not predict such an interaction, the obtained results indicated a significant interaction between concepts and levels of stimulus variety for irrelevant focusing. While the intra- and interdimensional shifts produced the most focusing for the conjunctive rule, the control or no shift condition produced the most focusing for the inclusive disjunctive rule. The results failed to support Morrisett and Hovland's (1959) conclusions that an intermediate mode of variety accounts for optimal performance. No differences in the total number of trials to solution emerged for levels of stimuli on the transfer task. The interaction obtained did indicate that if irrelevant focusing improves learning for the disjunctive rule, but not the conjunctive rule, no variety should be used for teaching either concept rule. If, however, irrelevant focusing were significantly related to concept solution for the conjunctive rule, the intra- and interdimensional modes of variety might provide the optimal conditions for irrelevant focusing. The significance of irrelevant focusing has already emerged from earlier analyses and will be explored further in discussions of the ex post facto results.

Saliency x Stimulus Variety

Although no predictions were made for the interaction of these variables, consistent and significant interactions were obtained for the number of positive trials to solution and for the total number of trials to solution. In both analyses the greatest number of trials occurred for the interdimensional condition when shape was relevant, and for the intradimensional condition when color was relevant. The analysis indicated the effect of a stimulus pair when its dimensions were approximately equal in saliency and when its dimensions were significantly different in saliency. Solution was most efficient when a contrast between dimensions was employed, and least efficient when both relevant and irrelevant dimensions were similar in saliency. A contrast between either relevant and irrelevant dimensions or "high" salient and "low" salient dimensions has accompanied most of the significant findings reported thus far. This result will now be discussed from ex post facto data.

Ex Post Facto Findings

A question arises from the ex post facto analysis as to how Ss came to solve a concept while focusing on the irrelevant dimension. From these analyses it has been indicated that although relevant focusers appeared to switch from the relevant dimension before their solution trial, a comparable shift was not apparent for the irrelevant focusers. Instead of switching, irrelevant focusers appeared to be looking to the relevant dimension and choosing a solution without focusing. Indeed, had the irrelevant focusers switched to relevant focusing, a significant negative correlation could not have been achieved, as focusing would have consumed additional card choices. Apparently, irrelevant focusing provided more useable information than did relevant focusing for the conjunctive rule.

The data place in doubt some of what has been conjectured about the nature of the conjunctive and disjunctive rules. Bruner et al. (1956) have described the conjunctive rule as a search for positive instances and the disjunctive rule as a search for negative instances. In the present study, however, this relationship is reversed for the conjunctive rule.

Generally, Ss solving a conjunctive task are expected to focus gradually upon the relevant dimension because of nonreinforcing experiences with the irrelevant dimension. Duncan (1965) predicted as much, but found, as did the present study, unexpected results. The effect of nonreinforcing experiences upon concept solution was called "nonresponse mediation" by Duncan; Ss experiencing a single negative instance would generalize the result to other negative instances of the same class. Ss would thereby learn to avoid the irrelevant dimension and gradually learn to focus upon the relevant dimension. However, nonresponse mediation in Duncan's study did not occur. The knowledge that a specific class was wrong did not reduce Ss' probability of responding to other members of that class. Similarly, the irrelevant focusers did not act according to their nonreinforcing experience, but continued to seek and focus upon the irrelevant dimension.

An alternative to nonresponse mediation that would have similar facilitating effects upon performance has been suggested by Kendler and Karasik (1958). They propose that Ss may respond to relevant dimensions with a common implicit response and to irrelevant dimensions with a separate implicit response. Using words instead of dimensions for their learning task, they have provided evidence that implicit response differentiation does occur and does facilitate performance. Response differentiation seems especially tenable for two dimensional concept tasks in which one dimension is relevant and the other is irrelevant. In this special case, focusing on the irrelevant dimension tells S, in effect, what the solution is not; therefore, looking to the other dimension increases the probability of a correct solution. The sooner S learns the nonresponse, the sooner he solves the concept; thus, establishing a negative relationship between irrelevant focusing and card choices to solution. Response differentiation can work in similar ways for the relevant focuser, with two exceptions. First, as the subject focuses on perhaps every third trial, the periodic reinforcement he receives may be insufficient for him to solve the problem, or even to be assured that the dimension focused upon is the relevant one. This is in contradistinction to the irrelevant focuser, who after several focuses must believe with increasing confidence that the dimension is irrelevant. Second, if S is unsure of the relevant dimension, he may test a second, and in this case, irrelevant dimension by focusing. The response differentiation is complete when S is assured of the irrelevant dimension and returns to the values of the relevant dimension in order to state a solution. Different processes, however, have led the relevant focuser to use more trials, thereby establishing a positive relation between relevant focusing and the number of trials to solution. In effect, the longer S remains a relevant focuser without being assured that the dimension is relevant, the higher and more positive is the relationship.

Alternatives may be devised to test for response differentiation. One such alternative would be to increase the number of irrelevant dimensions in order to reduce the advantage of irrelevant focusing. Irrelevant focusing should become proportionately inefficient as the number of irrelevant dimensions is increased. Whereas previously S could learn the relevant dimension by learning what it was not, S now finds other alternative dimensions, any one of which could be relevant. Focusing should tend to shift to the relevant dimension, and the direction of the correlations between irrelevant focusing and trials to solution should reverse.

Bruner et al. (1956) suggest that human Ss prefer a direct test of any hypothesis, and to illustrate this point, they describe the perhaps familiar analogy of S determining whether a white door or a black door leads to a reward. If S hypothesizes that the white door is correct, he can test his hypothesis by either a direct or indirect method. If he chooses to make a direct test of his hypothesis, he opens the white door; if he chooses an indirect test, he will open the black door, believing all the time that it does not lead to the reward. Although little evidence has been advanced, the transformation that is necessary when the indirect test is chosen (i.e., if the black door is wrong then the white one is correct, or if the black door is correct then the white one is incorrect) has provided rationale for why the conjunctive rule in practice, but not theory, is consistently easier than the disjunctive rule. Perhaps to explore this traditional explanation is to posit new hypotheses as to how learners can effectively employ irrelevant aspects of the stimulus display.

Chapter 6

Summary

Recent experiments in concept attainment have introduced type of concept rule as a variable. These experiments have established a logical order of difficulty for the conjunctive, inclusive disjunctive, exclusive disjunctive, and biconditional rules, with decision trees registering the number of interior nodes (decisions) as an index of difficulty. This logical explication has indicated that the conjunctive and inclusive disjunctive concepts are of equal difficulty and that the exclusive disjunctive and biconditional concepts, although more difficult than the former pair, are, in themselves, equal in difficulty. The results of empirical investigations have differed from what one might conclude from logical explications, and have reported an order of increasing difficulty for the conjunctive, inclusive disjunctive, exclusive disjunctive, and biconditional rules respectively. Related investigations have indicated that some deficits in learning may not lie with an intellectual inability to form associations or to solve problems so much as with an inability to attend to critical features of the task. This research suggests that attentional factors may account for the conjunctive and inclusive disjunctive rules being unequal in difficulty, despite logical explications which have equated them. An interaction of attentional factors with concept rules is suggested.

A study was conducted to determine the effects of saliency, concept rule, and stimulus variety upon number of trials to solution and focusing strategy. A prediction of special interest was that there would be a concept rule x saliency interaction. A 2 x 2 x 3 design combined concept rule (conjunctive, inclusive disjunctive), saliency ("high" and "low" determined by mean performance of Ss in preliminary research), and stimulus variety (intradimensional shift, interdimensional shift, and no shift). Sixty college students completed a warm-up problem, a training problem, a shift problem (or no shift in the case of controls), and a transfer-to-new-stimuli problem. Dependent measures analyzed were (a) number of correct card choices, (b) number of incorrect card choices, (c) number of total card choices, (d) time to solution, (e) strength of focusing on the relevant dimension, and (f) strength of focusing on the irrelevant dimension. The focusing measures represented a technique for separating aptitude and attentional factors in concept learning. Analyses of variance and regression analyses with slopes tests were employed; the latter included the application of the Neyman-Johnson technique in order to determine critical regions of significance.

Analyses uncovered significant interactions between Saliency and Concept Rule for the dependent measures, incorrect card choices and strength of relevant focusing; a Concept Rule x Stimulus Variety interaction for the dependent measure, strength of irrelevant focusing; and Stimulus Variety x Saliency interactions for the dependent measures, positive and total instances to solution. The hypothesized Concept Rule x Saliency interaction for total card choices was not significant. Regression analyses uncovered significantly different slopes for focusing in the color relevant and shape relevant conditions. The results suggest the need for new theoretical alternatives to traditional focusing which must account for the superiority in learning achieved by focusing on the irrelevant dimension in the conjunctive rule. One alternative explored in the study was that of response differentiation.

The research indicated the functions of the irrelevant and relevant dimensions in solving two dimension concept identification tasks and contradicted older descriptions of the conjunctive rule stated by Bruner (1956). The results suggest that (a) traditional expectations of the conjunctive rule, which indicate that the most direct test yields the greatest information, do not apply to two-dimension concept attainment tasks and (b) greatest focusing on a transfer task can be achieved with small shift paradigms (change in solution only). Methodological implications include application of regression analyses to focus strategy research.

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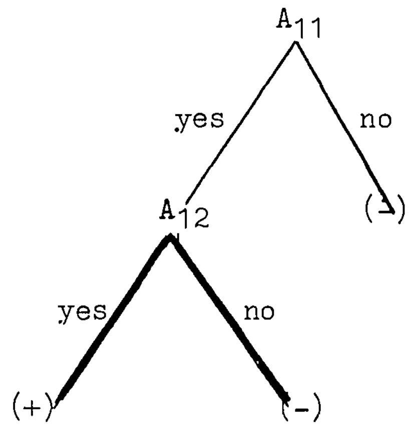
APPENDIX

Appendix A

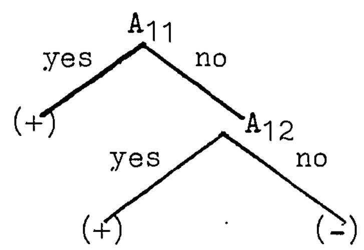
Conjunction. Positive instances have both characteristics.

$(A_{11} + A_{12})$



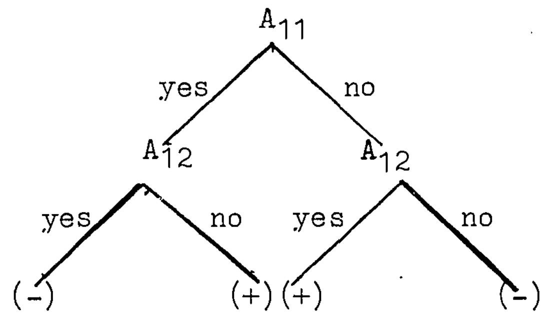
Inclusive disjunction. Positive instances have either

$(A_{11}$ or $A_{12})$ or $(A_{11} + A_{12})$



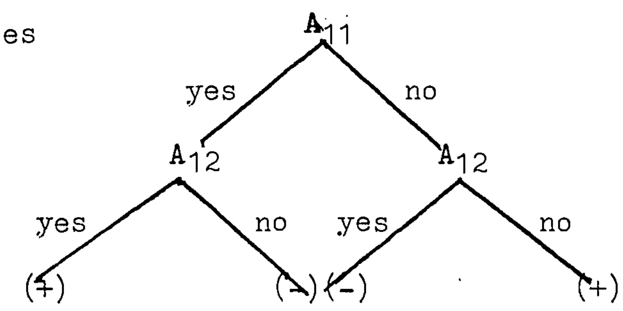
Exclusive disjunction. Positive instances have

$(A_{11}$ or $A_{12})$ (not both)



Biconditional. Positive instances have

$(A_{11} + A_{12})$ or $-(A_{11} + A_{12})$



Appendix B

Shift	Example Card	Deck	Conjunctive and Inclusive Disjunctive	
			Irrelevant Salient	Relevant Salient
Intra-dimensional	Red L, Red L	T	Red, Red	L,L
	Green S, Red L	T	Green, Red	S,L
	Red△, Green○	D_1	Red, Green	Triangle, Circle
	Vertical-Dot Below, Horizontal-Dot Above	D_3	Dot Below, Horizontal Line	Dot Below, Horizontal Line
Inter-dimensional	Red L, Red L	T	Red, Red	L,L
	Green S, Red L	T	Green, Red	S,L
	(a) No Border Triangle, Border Triangle (b) No Border Green, Border Green	D_2	No Border, Border (a)	No Border, Border (b)
	Vertical-Dot Below, Horizontal-Dot Above	D_3	Dot Below, Horizontal Line	Dot Below, Horizontal Line
Control	Red L, Red L	T	Red, Red	L,L
	Green S, Red L	T	Green, Red	S,L
	Red L, Green S	T	Red, Green	L,S
	Vertical-Dot Below, Horizontal-Dot Above	D_3	Dot Below, Horizontal Line	Dot Below, Horizontal Line

Appendix C

INSTRUCTIONS

Conjunctive, Training

This is an experiment to see how you think. As you can see, there are 16 cards laid out on the table. Each card contains one small letter and one large letter. The small letters and large letters vary in both color and shape. A small letter for example, can be either an "s" or an "l" or either green or red. The same holds for large letters. Notice that the small letter on all the cards is on the left, the large letter on the right. They never change positions.

For purposes of this experiment a concept will be considered to be a certain set of these cards. A concept about these cards has been chosen. Your job will be to find out the concept as efficiently as possible, in a manner that will be described to you.

An example of the type of concept we are dealing with might be all those cards which contain both a small green letter and a large "L". Would you please point out all the cards here which have the property of having both a small green letter and a large "L". (4 cards)

Please keep in mind that with the type of concepts we are dealing with, just one property of the small letters is required (green, red, "s", or "l") and one property (green, red, "s", or "l") is required for the large letters. In other words, small green, small "s" is not a concept we are dealing with, because this has two properties of one figure. Each concept, again, requires that its examples have just one property of the small letter and one property of the large letter.

I will give you a card that is an example of the concept. Your job will be to try other cards, one at a time. I will tell you after each choice whether or not these are examples of the concept. You may guess at the concept at any point, but wrong guesses will result in a subtraction from your score. However, there is obviously no penalty for picking particular cards which are not examples of the concept. Your score will depend on how few cards you have to try before you are sure of what the concept is. When you have arrived at the concept, tell me what it is. If you are correct, that problem will be finished and we will go on to another. Time is not a factor, only the number of cards you have to try. You may rearrange the cards during trials in any way that may be helpful to you. We will make two rows at the top, one for the cards that are examples of the concept, and a row for those that are not. When you choose a card, hand it to me. Do you have any questions?

Conjunctive, D_1

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both color and shape. For this problem however, the small figure can be either a circle or a triangle or, as before, either green or red. The same holds for the large figures. Would you please point out all the cards here which have the property of having both a small green figure and a large circle. (4 cards)

Keep in mind that with the type of concepts we are dealing with just one property of the small figures is required and one property of the large figures. These properties are green, red, triangle, and circle. Each concept requires that its examples have just one property of the smaller figure and one property of the large figure. Do you have any questions?

Conjunctive, $D_{2(a)}$ (color relevant)
(Subjects receive Deck 2(a) or Deck 2(b) not both)

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both shape and whether or not the shape has a border. For this problem the small figures can be either a circle or a triangle or be bordered or not bordered. The same holds for the large figures. Would you please point to all the cards here which have the property of having both a small circle and a large bordered figure. (4 cards)

Keep in mind that with the type of concepts we are dealing with, just as before, one property of the small figures is required and one property of the large figures. These properties are circle, triangle, bordered, not bordered. Each concept requires that its examples have just one property of the small figure and one property of the large figure. Do you have any questions?

Conjunctive, $D_{2(b)}$ (shape relevant)

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both color and whether or not the figure has a border. For this problem the small figure can be either green or red or either bordered or not bordered. The same holds for the large figures. Would you please point to all the cards here which have the property of having both a small green figure and a large bordered figure. (4 cards)

Keep in mind that with the type of concepts we are dealing with, just as before, one property of the small figures is required and one property of the large figures. These properties are green, red, bordered, not bordered. Each concept requires that its examples have just one property of the small figure and one property of the large figure. Do you have any questions?

Conjunctive, D_3

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both the position of a dot and the position of an interior line. For this problem the small figure can have either a dot above the figure or below the figure or either an interior horizontal line or vertical line. The same holds for the large figures. Would you please point to all the cards here which have the property of having a dot above the small figure and a vertical line in the large figure. (4 cards)

Keep in mind that with the type of concepts we are dealing with, just as before, one property of the small figures is required and one property of the large figures. These properties are dot above, dot below, interior vertical line, interior horizontal line. Each concept requires that its examples have just one property of the small figure and one property of the large figure. Do you have any questions?

INSTRUCTIONS

Inclusive, Training

This is an experiment to see how you think. As you can see, there are 16 cards laid out on the table. Each card contains one small letter and one large letter. The small letters and large letters vary in both color and shape. A small letter for example can be either an "s" or an "l" or either green or red. The same holds for large letters. Notice that the small letter on all the cards is on the left, the large letter on the right. They never change positions.

For purposes of this experiment a concept will be considered to be a certain set of these cards. A concept about these cards has been chosen. Your job will be to find out the concept as efficiently as possible, in a manner that will be described to you.

An example of the type of concept we are dealing with might be all those cards which contain <u>either</u> a small green letter <u>or</u> a large "L" <u>or</u> <u>both</u>. Would you please point out all the cards here which have the property of having either a small green letter or a large "L" or both. (12 cards)

Please keep in mind that with the type of concept we are dealing with, just one property of the small letters is required (green, red, "s" or "l") and one property (green, red, "s" or "l") is required for the large letters. In other words, small green, small "s" is not a concept we are dealing with, because this has two properties of one figure. Each concept, again, requires that its examples have one property of the small letter or one property of the large letter.

I will give you a card that is an example of the concept. Your job will be to try other cards, one at a time. I will tell you after each choice whether or not these are examples of the concept. You may guess at the concept at any point, but wrong guesses will result in a subtraction from your score. However, there is obviously no penalty for picking particular cards which are not examples of the concept. Your score will depend on how few cards you have to try before you are sure of what the concept is. When you have arrived at the concept, tell me what it is. If you are correct, that problem will be finished and we will go on to another. Time is not a factor, only the number of cards you have to try. You may rearrange the cards during trials in any way that may be helpful to you. We will make two rows at the top, one for the cards that are examples of the concept, and a row for those that are not. When you choose a card, hand it to me. Do you have any questions?

Inclusive, D_1

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both color and shape. For this problem, however, the small figure can be either a circle or a triangle, or, as before, either green or red. The same holds for the large figures. Would you please point out all the cards here which have the property of having either a small green figure or a large circle or both. (12 cards)

Keep in mind that with the type of concepts we are dealing with, just one property of the small figures is required and one property of the large figures. These properties are green, red, triangle, and circle. Each concept requires that its examples have either one property of the small letter or one property of the large letter. Do you have any questions?

Inclusive, $D_{2(a)}$ (color relevant)

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both shape and whether or not the shape has a border. For this problem the small figure can be either a circle or a triangle or be bordered or not bordered. The same holds for the large figures. Would you please point to all the cards here which have the property of having either a small circle or a large-figure-not-bordered, or both. (12 cards)

Keep in mind that with the type of concepts we are dealing with, just one property of the small figures is required and one property of the large figures. These properties are circle, triangle, bordered, or not bordered. Each concept requires that its example have either one property of the small letter or one property of the large letter. Do you have any questions?

Inclusive, $D_{2(b)}$ (shape relevant)

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both color and whether or not the figure has a border. For this problem the small figure can be either green or red or either bordered or not bordered. The same holds for the large figures. Would you please point out all the cards here which have the property of having either a small green figure or a large-figure-not-bordered, or both. (12 cards)

Keep in mind that with the type of concepts we are dealing with, just one property of the small figures is required and one property of the large figures. These properties are green, red, bordered, not bordered. Each concept requires that its examples have either one property of the small letter or one property of the large letter. Do you have any questions?

Inclusive, D_3

Now again I have placed 16 cards out on the table. Each card contains as before one small figure and one large figure. The small figures and large figures vary in both the position of a dot and the position of an interior line. For this problem the small figure can have either a dot above the figure or below the figure or either an interior horizontal line or vertical line. The same holds for the large figures. Would you please point to all the cards here which have the property of having either a dot above the small figure or a vertical line in the large figure, or both. (12 cards)

Keep in mind that with the type of concepts we are dealing with, just as before, one property of the small figures is required and one property of the large figures. These properties are dot above, dot below, interior vertical line, interior horizontal line. Each concept requires that its examples have either one property of the small letter or one property of the large letter. Do you have any questions?

Appendix D

TABLE 4.11

Mean Scores and Analysis of Variance for Positive Trials to Solution, Problem 2

Saliency	Conjunctive	Disjunctive
Rel. Salient	1.33	4.27
Irrel. Salient	1.73	5.27

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	156.82	1	156.82	32.53**
Saliency	7.35	1	7.35	1.52
A x B	1.35	1	1.35	--
S (AB)	270.13	56	4.82	

$^{**}p < .01$

TABLE 4.12

Mean Scores and Analysis of Variance for Negative Trials to Solution, Problem 2

Saliency	Conjunctive	Disjunctive
Rel. Salient	1.33	1.20
Irrel. Salient	0.93	2.20

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	4.82	1	4.82	3.17
Saliency (B)	1.35	1	1.35	--
A x B	7.35	1	7.35	4.84*
S (AB)	85.07	56	1.52	

*$p < .05$.

TABLE 4.13

Mean Scores and Analysis of Variance for Total Trials to Solution, Problem 2

Saliency	Conjunctive	Disjunctive
Rel. Salient	2.67	4.93
Irrel. Salient	2.67	7.74

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	187.27	1	187.27	19.23**
Saliency (B)	24.07	1	24.07	2.47
A x B	24.07	1	24.07	2.47
S (AB)	545.33	56	9.74	

**$p < .01$

TABLE 4.14

Mean Scores and Analysis of Variance for Time to Solution, Problem 2

Saliency	Conjunctive	Disjunctive
Rel. Salient	74.33	233.47
Irrel. Salient	94.40	372.67

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	717445.35	1	717445.35	17.89**
Saliency (B)	95122.01	1	95122.01	2.37
A x B	53222.82	1	53222.82	1.33
S (AB)	2245246.00	56	40093.68	

$^{**}p < .01$

TABLE 4.15

Mean Scores and Analysis of Variance for Focusing on the Relevant Dimension, Problem 2

Saliency	Conjunctive	Disjunctive
Rel. Salient	0.39	0.15
Irrel. Salient	0.15	0.22

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	0.110	1	0.110	1.93
Saliency (B)	0.100	1	0.100	1.74
A x B	0.376	1	0.376	6.60*
S (AB)	2.626	56	0.057	

*$p < .05$.

TABLE 4.16

Mean Scores and Analysis of Variance for Focusing on the Irrelevant Dimension, Problem 2

Saliency	Conjunctive	Disjunctive
Rel. Salient	0.32	0.19
Irrel. Salient	0.55	0.29

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rule (A)	0.610	1	0.610	6.98*
Saliency (B)	0.415	1	0.415	4.07*
A x B	0.067	1	0.067	--
S (AB)	5.697	56	0.102	

*$p < .05$

TABLE 4.17

Mean Scores and Analysis of Variance for Positive Trials to Solution, Problem 3

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	1.40	2.00	3.60	4.40
Inter-shift	2.00	1.80	6.40	3.00
Control	1.20	1.60	1.60	2.80

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	58.02	1	58.02	28.02**
Saliency (B)	0.15	1	0.15	--
Stimulus Variety (C)	23.70	2	11.85	5.72*
A x B	2.02	1	2.02	--
A x C	10.83	2	5.42	2.62
B x C	21.70	2	10.85	5.24*
A x B x C	11.63	2	5.82	2.81
S (ABC)	99.60	48	2.07	

*$p < .05$
**$p < .01$

TABLE 4.18

Mean Scores and Analysis of Variance for Negative Trials to Solution, Problem 3

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	1.20	0.80	1.00	1.60
Inter-shift	2.40	0.60	1.60	0.80
Control	1.80	1.40	1.20	1.40

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	0.15	1	0.15	--
Saliency (B)	2.82	1	2.82	1.48
Stimulus Variety (C)	0.93	2	0.47	--
A x B	2.82	1	2.82	1.48
A x C	1.20	2	0.60	--
B x C	5.73	2	2.87	1.51
A x B x C	0.13	2	0.07	--
S (ABC)	91.20	48	1.90	

TABLE 4.19

Mean Scores and Analysis of Variance for Total Trials to Solution, Problem 3

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	2.60	2.80	4.80	6.00
Inter-shift	4.40	2.40	8.00	3.80
Control	3.00	3.00	2.80	3.60

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rule (A)	48.60	1	48.60	8.10**
Saliency (B)	6.67	1	6.67	1.11
Stimulus Variety (C)	24.43	2	12.22	2.04
A x B	0.07	1	0.07	--
A x C	19.30	2	9.65	1.61
B x C	44.63	2	22.32	3.72*
A x B x C	8.03	2	4.02	--
S (ABC)	288.00	48	6.00	

*$p < .05$.
**$p < .01$.

TABLE 4.20

Mean Scores and Analysis of Variance for Time to Solution, Problem 3

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	78.80	79.20	269.00	210.60
Inter-shift	162.20	54.20	570.60	149.60
Control	72.80	76.00	94.80	177.40

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	375092.27	1	375092.27	7.07*
Saliency (B)	104667.27	1	104667.27	1.97
Stimulus Variety (C)	167466.63	2	83783.32	1.58
A x B	35624.07	1	35624.07	--
A x C	90493.43	2	45246.72	--
B x C	258541.03	2	129270.52	2.44
A x B x C	99039.43	2	49519.72	--
S (ABC)	2546637.60	48	53054.95	

*$p < .05$.

TABLE 4.21

Mean Scores and Analysis of Variance for Focusing on the Relevant Dimension, Problem 3

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	0.17	0.15	0.14	0.19
Inter-shift	0.14	0.10	0.15	0.31
Control	0.56	0.20	0.17	0.26

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rule (A)	0.005	1	0.005	--
Saliency (B)	0.006	1	0.006	--
Stimulus Variety (C)	0.220	2	0.110	1.96
A x B	0.215	1	0.215	3.84
A x C	0.195	2	0.097	1.73
B x C	0.104	2	0.052	--
A x B x C	0.090	2	0.045	--
S (ABC)	2.673	48	0.056	

TABLE 4.22

Mean Scores and Analysis of Variance for Focusing on the Irrelevant Dimension, Problem 3

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	0.60	0.61	0.00	0.11
Inter-shift	0.41	0.72	0.16	0.07
Control	0.06	0.35	0.20	0.28

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	1.555	1	1.555	16.03**
Saliency (B)	0.204	1	0.204	2.10
Stimulus Variety (C)	0.172	2	0.086	--
A x B	0.106	1	0.106	1.09
A x C	0.971	2	0.485	5.00*
B x C	0.041	2	0.020	--
A x B x C	0.152	2	0.076	--
S (ABC)	4.650	48	0.097	

*$p < .05$.
**$p < .01$.

TABLE 4.23

Mean Scores and Analysis of Variance for Positive Trials to Solution, Problem 4

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	1.60	1.60	3.40	4.40
Inter-shift	1.40	1.60	3.20	5.40
Control	1.40	1.40	3.20	4.80

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rule (A)	98.82	1	98.82	34.55**
Saliency (B)	10.42	1	10.42	3.64
Stimulus Variety (C)	0.43	2	0.22	--
A x B	8.82	1	8.82	3.08
A x C	0.63	2	0.32	--
B x C	1.23	2	0.62	--
A x B x C	0.63	2	0.32	--
S (ABC)	137.20	48	2.86	

$^{**}p < .01$.

TABLE 4.24

Mean Scores and Analysis of Variance for Negative Trials to Solution, Problem 4

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	1.40	1.20	1.40	1.20
Inter-shift	2.60	1.00	1.00	1.60
Control	1.20	0.80	1.00	1.40

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	0.15	1	0.15	--
Saliency (B)	0.82	1	0.82	--
Stimulus Saliency (C)	2.03	2	1.02	--
A x B	3.75	1	3.75	1.89
A x C	1.30	2	0.65	--
B x C	0.63	2	0.32	--
A x B x C	3.10	2	1.55	--
S (ABC)	95.20	48	1.98	

TABLE 4.25

Mean Scores and Analysis of Variance for Total Trials to Solution, Problem 4

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	3.00	2.80	4.80	5.60
Inter-shift	4.00	2.00	4.20	7.00
Control	2.60	2.20	4.20	6.20

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	98.82	1	98.82	17.37**
Saliency (B)	3.75	1	3.75	--
Stimulus Variety (C)	2.50	2	1.25	--
A x B	22.02	1	22.02	3.87
A x C	0.63	2	0.32	--
B x C	0.70	2	0.35	--
A x B x C	9.23	2	4.62	--
S (ABC)	273.20	48	5.69	

** $p < .01$.

TABLE 4.26

Mean Scores and Analysis of Variance for Time to Solution, Problem 4

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	127.60	113.80	209.40	270.40
Inter-shift	112.00	78.60	232.40	524.00
Control	87.80	67.60	236.00	517.00

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	818768.02	1	818768.02	12.37**
Saliency (B)	133576.02	1	133576.02	2.02
Stimulus Variety (C)	36466.43	2	18233.22	--
A x B	204750.42	1	204750.42	3.09
A x C	98844.43	2	49422.22	--
B x C	37563.63	2	18781.82	--
A x B x C	47676.43	2	23838.22	--
S (ABC)	3177168.80	48	66191.02	

** $p < .01$.

TABLE 4.27

Mean Scores and Analysis of Variance for Dot Focusing, Problem 4

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	0.10	0.25	0.17	0.31
Inter-shift	0.19	0.17	0.32	0.08
Control	0.20	0.10	0.12	0.09

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rules (A)	0.002	1	0.002	--
Saliency (B)	0.004	1	0.004	--
Stimulus Variety (C)	0.068	2	0.034	--
A x B	0.009	1	0.009	--
A x C	0.029	2	0.014	--
B x C	0.215	2	0.108	2.04
A x B x C	0.055	2	0.027	--
S (ABC)	2.548	48	0.053	

TABLE 4.28

Mean Scores and Analysis of Variance for Line Focusing, Problem 4

Stimulus Variety	Conjunctive		Disjunctive	
	Rel. Sal.	Irrel. Sal.	Rel. Sal.	Irrel. Sal.
Intra-shift	0.15	0.33	0.24	0.20
Inter-shift	0.26	0.37	0.20	0.18
Control	0.67	0.60	0.26	0.17

Analysis of Variance

Source of Variation	SS	DF	MS	F
Concept Rule (A)	0.526	1	0.547	7.81**
Saliency (B)	0.003	1	0.003	--
Stimulus Variety (C)	0.451	2	0.226	3.23*
A x B	0.056	1	0.056	--
A x C	0.426	2	0.213	3.06
B x C	0.063	2	0.031	--
A x B x C	0.026	2	0.013	--
S (ABC)	3.782	48	0.070	

*$p < .05$.
**$p < .01$.